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Investment-promoting policies in open economies

The importance of intergenerational and international distributional effects

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Using an intertemporal equilibrium model with overlapping generations, this paper explores how intergenerational and international distributional effects, in addition to intertemporal efficiency impacts, affect the macroeconomic consequences of investment-promoting policies. Whereas the intergenerational distributional effects may weaken the initial expansionary effects of an investment tax credit, they strengthen the short-run positive effects on domestic demand exerted by a lower corporate tax rate. The paper also explores several policies aimed at neutralizing the intergenerational and international distributional consequences of investment-promoting policies.

1. Introduction

In recent years, policymakers have become increasingly concerned about the adverse effects of capital income taxation on capital accumulation. At the same time, the growing international integration has led to increased attention to how fiscal policies impact international capital and trade flows. This study explores the macroeconomic effects of two alternative policies aimed at stimulating domestic investment. The first is a reduction in the source-based capital income tax (CIT) and the second the introduction of an investment tax credit (ITC). These policies have been analyzed in a closed-economy setting by Auerbach and Kotlikoff (1987) and Goulder and Summers (1989), who adopted numerical intertemporal equilibrium models

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with, respectively, overlapping generations and a representative infinitely-lived household. The present paper extends their analysis to an analytical overlapping generations model of a small open economy that is integrated in world financial markets. Behavioral relationships are grounded in intertemporal optimization and the model solves for a full intertemporal equilibrium with perfect foresight. Accordingly, the study integrates, on the one hand, traditional public finance issues, such as intertemporal efficiency and intergenerational and international incidence, and, on the other hand, macroeconomic effects of fiscal policies on investment, saving, consumption, net foreign assets, the external current account, and the trade balance.

In order to analyze the effects of investment-promoting policies on the external current account, one can employ the identity between the current account balance and the difference between domestic saving and domestic investment. The conventional wisdom from this identity is that, in an integrated world financial market, an increase in investment brought about by investment incentives will result in a deterioration of the external current account. In this connection, Summers (1988) argues that, in a world of international capital mobility, it is crucial to distinguish between, on the one hand, policies that stimulate domestic saving, and, on the other hand, those targeted at promoting domestic investment because these two different types of policies are likely to exert opposite effects on domestic absorption and the external current account. Bovenberg (1989) shows, however, that international capital mobility is not a sufficient condition for investment incentives to worsen the initial current account by boosting short-run domestic absorption. In particular, if foreign and domestic commodities are imperfect substitutes in demand, domestic capital accumulation may raise domestic saving on account of both a rise in real interest rates and the anticipation of a terms-of-trade loss.

The present paper complements the analysis in Bovenberg (1989) by identifying two other channels through which investment-promoting policies affect domestic saving and consumption, namely intergenerational and international distributional effects. Whereas it does not allow for imperfect substitutability between commodities, this paper extends the analysis in Bovenberg (1989) in two directions. First, the paper adopts the overlapping generations models developed by Yaari (1965), Blanchard (1984, 1985) and Weil (1989) to model consumption behavior. In contrast to the household model of a representative infinitely-lived agent employed by Bovenberg (1989), the overlapping generations model allows for a meaningful role of intergenerational transfers and, therefore, does not exhibit debt-neutrality. This model has been used to explore the effects of the intergenerational transfers associated with budget deficits, but the current paper applies it to show how the distributional effects of alternative tax systems impact aggregate saving and, therefore, the external current account [see also Engel

and Kletzer (1990)]. The model also allows for the exploration of the sensitivity of the results with respect to the degree of disconnectedness of the generations.

The second extension involves foreign ownership of the domestic capital stock. In the presence of foreign ownership, unanticipated domestic policies can affect foreign wealth and net foreign assets by changing the value of the domestic capital stock. Hence, this extension enables the paper to analyze how this implicit taxation, or subsidization, of the foreign owners of the domestic capital stock impacts the international distribution of wealth, net foreign assets, and the external current account and trade balances.

The two extensions result in important differences between the two investment-promoting policies. Intuitively, given a certain objective for capital accumulation, a reduction in the CIT yields a higher value of the domestic capital stock and lower after-tax wages than the ITC does. Accordingly, compared with the ITC, a lower CIT benefits the owners of the domestic capital stock and hurts wage earners. If domestic households own the domestic capital stock in the initial equilibrium, current generations at home gain at the expense of future generations because they capitalize the higher after-tax capital earnings but, given the overlapping generations structure, absorb only part of the lower wages. However, if foreigners own the domestic capital stock initially, foreigners gain while domestic households – especially the currently alive – lose.

These distributional effects influence the external current account through their impact on domestic saving. This illustrates that investment-promoting policies affect the saving–investment balance not only by impacting the incentive to invest domestically but also by influencing the intergenerational and international distribution of resources. This paper investigates all these transmission channels – incentives to invest in domestically-located capital and the intergenerational and international distribution – and is thus able to determine the overall macroeconomic consequences for the external current account. In particular, it identifies the conditions under which the distributional impacts of investment-promoting policies raise saving, thereby offsetting the initial deterioration of the external account due to stronger investment.

The paper also explores policies aimed at neutralizing the distributional consequences of investment-promoting policies. These policies serve two purposes. First, they ensure that investment-promoting policies can be Pareto-welfare improving by allowing all generations to share in the overall efficiency gains. Second, they enable separation of the efficiency impact of investment-promoting policies from the distributional effects of these policies. The separation of efficiency and equity effects is possible only because of the assumptions of a small open economy (i.e. a fixed world rate of return) and exogenous labor supply. Under these assumptions the domestic capital stock

does not depend on the income distribution. Hence, there is no feedback from the intergenerational distribution to the efficiency gains due to capital deepening.¹

A growing body of literature has investigated the effects of capital income taxation in intertemporal equilibrium models that allow for international capital mobility [see, for example, Frenkel and Razin (1987)]. The current study differs from previous studies in several important respects. Most importantly, it combines adjustment costs in investment with overlapping generations determining saving behavior. In contrast to Frenkel and Razin (1986a, b) and van Wijnbergen (1986), it introduces endogenous investment, capital accumulation, and output, and therefore can explore the interaction between capital accumulation, consumption, and saving. Whereas Keuschnigg (1991) and Engel and Kletzer (1990) introduce capital accumulation in a model with overlapping generations, these papers assume that physical capital is perfectly mobile internationally. However, the current study distinguishes between, on the one hand, perfect mobility of financial capital, and, on the other hand, imperfect mobility of physical capital. In particular, adjustment costs in investment prevent physical capital from instantaneously relocating between countries. The incorporation of adjustment costs allows for a more realistic assessment of the response of investment, and, therefore, the external current account and trade balances. It has also important implications for the intergenerational distribution of resources and, therefore, saving behavior.

Lipton and Sachs (1983), Goulder and Eichengreen (1989), and Sen and Turnovsky (1990) allow for endogenous investment with adjustment costs in intertemporal equilibrium models of open economies. However, these models do not incorporate (disconnected) overlapping generations. The current paper reveals that the interaction between, on the one hand, adjustment costs in capital accumulation and, on the other hand, overlapping generations determining saving behavior, plays a crucial role in transmitting shocks in domestic investment to domestic saving.

The model differs from numerical studies [see, for example, Lipton and Sachs (1983); Goulder and Eichengreen (1989); Soderlind (1990) and Keuschnigg (1991)] in presenting analytical solutions that have an intuitive interpretation. These solutions explicitly reveal how several major structural parameters affect the transmission of investment-promoting policies to saving, investment, and the external trade and current accounts. In particular, it identifies the roles of, among other things, adjustment costs in investment, the birth rate of new generations, foreign ownership of domestic capital, substitution between labor and capital in domestic production, the

¹See also Auerbach and Kotlikoff (1987) for the measurement of pure efficiency effects of tax reforms in overlapping generations models.

initial tax rate on capital income, and the rate of return on world capital markets.

Most analytical studies of intertemporal equilibrium models of open economies formulate two-period models [see, for example, Frenkel and Razin (1986c) and van Wijnbergen (1986)]. The current paper, in contrast, explores the entire transition path to a new long-run equilibrium. The results reveal that a two-period structure, which incorporates only short-run and long-run results, cannot fully characterize the dynamics of the adjustment path. For example, a policy shock may benefit the generations that are alive at the time the policy is implemented and the generations that are born when the economy approaches its new long-run equilibrium. However, generations born during the transition may lose. In this connection, the study identifies several non-monotonic adjustment paths. Furthermore, compared with two-period models, the multiperiod model allows for a more realistic evaluation of the intertemporal impact of fiscal policies.

In incorporating both adjustment costs in investment and overlapping generations in an analytical intertemporal equilibrium model of a small open economy, the current study is closely related to Nielsen and Sørensen (1991). This latter paper examines several tax instruments, including the two investment-promoting policies explored here. However, it assumes that both foreign ownership and the initial tax rate on capital income are zero and, therefore, cannot investigate the international distribution and intertemporal efficiency effects and their macroeconomic implications.² Furthermore, compared with Nielsen and Sørensen (1991), the current paper pays more attention to the interpretation of the adjustment dynamics. Moreover, it examines the role of public debt policy and the composition of investment-promoting policies in ensuring that these policies are Pareto improving.

The remainder of this paper is organized as follows. Section 2 outlines the main elements of the intertemporal equilibrium model. Section 3 examines the solutions derived from the capital accumulation side of the model, which are used in section 4 to explore the consequences of the two policies for the intergenerational distribution of welfare. Sections 5 and 6 investigate the effects on, respectively, aggregate consumption and saving. Combining the implications for consumption, saving, and investment, reveals the consequences for the trade performance and the net foreign asset position, which are explored in section 7. Numerical simulations in section 8 illustrate the quantitative importance of the macroeconomic effects discussed in the previous sections. Section 9 analyzes three alternative ways to arrive at investment-promoting policies that are Pareto improving by properly controlling for international and intergenerational distributional impacts. Section 10 presents the main conclusions.

²In contrast to the current paper, Nielsen and Sørensen impose the restriction that the world rate of interest exceeds the discount rate.

2. The model

2.1. Consumption and saving behavior

The saving and consumption side of the model consists of an overlapping generations model attributable to Buiter (1989), which is a combination of a version developed by Yaari (1965) and Blanchard (1984, 1985) and a version due to Weil (1989). Following the Yaari–Blanchard model, each household faces a constant probability of passing away, θ .³ In the absence of an operative bequest motive, each household purchases (or sells) an annuity that pays a rate of return, θ . Accordingly, the real rate of return earned by a household on its financial wealth is the sum of the real rate of return on world capital markets, r , and the probability of death, θ .⁴

New households that are *not* linked through operative intergenerational transfers to older households are born at a constant rate, $(n + \theta)$.⁵ This birth rate measures the heterogeneity, or economic disconnectedness, of the population [see Weil (1989)]. Both the total population and labor supply grow at the rate n because all households inelastically supply the same amount of labor.⁶ At time $t \geq v$, the representative household of the generation born at time v maximizes the expected value of additive separable utility, adopting a subjective discount rate, δ :

$$U(v, t) = \int_t^{\infty} u(c(v, s)) e^{-\delta(s-t)} e^{-\theta(s-t)} ds \quad (2.1)$$

subject to a budget constraint

$$\dot{a}(v, t) = (r + \theta)a(v, t) + \omega(t) - c(v, t), \quad (2.2)$$

where $c(v, t)$ and $a(v, t)$ represent, respectively, consumption and financial wealth per capita at time $t \geq v$ of the generation born at time v . A dot above a variable denotes a time derivative. This paper assumes that every living household supplies one unit of homogeneous labor per capita and receives the same lump-sum transfer per capita, which can vary over time. Hence, non-capital disposable income (which is the sum of before-tax wages and

³One can also interpret this constant probability of death as the probability that a dynasty expires. By allowing for $\theta < 0$, one can allow for intra-dynasty growth.

⁴This is the reverse of life insurance. Instead of paying the insurance company in exchange for a payment to heirs in the event of death, the insured collect payments from the insurance company in exchange for disposal of their estate when they die. See also Blanchard (1984, 1985).

⁵Weil (1989) interprets this birth rate as the rate at which new dynasties enter the domestic economy. This rate depends on the proportion of newly-born children who are not 'loved'.

⁶Hence, the birth rate, $n + \theta$, and the death rate, θ , are distinct in this model. Blanchard (1984, 1985), in contrast, assumes that the birth rate equals the death rate (i.e. $n = 0$), while Weil (1989) abstracts from death (i.e. $\theta = 0$).

lump-sum transfers) per capita is age independent. It can be interpreted as the return to human capital and is denoted by $\omega(t)$. The intertemporal substitution elasticity of consumption is given by the reciprocal of the coefficient of relative risk aversion, $\sigma = -cu''(c)/u'(c)$. The domestic economy is assumed to be small relative to the rest of the world. Accordingly, the real rate of return, r , is fixed by world capital markets.

The optimization problem yields the following consumption function:

$$c(v, t) = \Delta[a(v, t) + \bar{h}(t)], \quad (2.3)$$

where $\bar{h}(t)$ represents per capita human wealth at time t , which is identical for all agents alive at that time because non-capital income does not depend on age:

$$\bar{h}(t) = \int_t^{\infty} [\omega(s)] e^{-(r+\theta)(s-t)} ds. \quad (2.4)$$

Also the propensity to consume out of total wealth, Δ , is age independent because all agents feature the same time horizon:

$$\Delta = r + \theta - \frac{r - \delta}{\sigma}. \quad (2.5)$$

Following Blanchard (1984, 1985), one can aggregate across generations to arrive at expressions in terms of per capita aggregate variables:

$$C(t) = \Delta[A(t) + H(t)] = \Delta W(t), \quad (2.6)$$

$$\dot{A}(t) = (r - n)A(t) + \omega(t) - C(t), \quad (2.7)$$

where the per capita aggregate variables are derived from the per capita generation-specific variables as follows:

$$X(t) = \int_{-\infty}^t x(v, t)(n + \theta) e^{-(n+\theta)(t-v)} dv, \quad X = C, A, \quad x = c, a, \quad (2.8)$$

and $H(t) = \bar{h}(t)$. $W(t) = A(t) + H(t)$ corresponds to per capita aggregate wealth at time t .

2.2. Production and investment

A neo-classical net production function represents a constant-returns-to-scale technology

$$y = f(k), \quad (2.9)$$

where y corresponds to output per capita (net of depreciation) of the single tradable commodity and k stands for the capital-labor ratio.⁷ The marginal productivity condition for labor represents the demand for labor:

$$w = f(k) - kf'(k), \quad (2.10)$$

where w represents the before-tax wage rate and $f'(k) = df(k)/dk$. In addition to the production technology (2.9), the production sector faces a second technology constraint – the installation function. This function was introduced by Uzawa (1969) to model adjustment costs associated with investment.⁸ With the labor force growing at the rate n and labor being immobile internationally, this installation function can be written as [see, for example, Bovenberg (1986)]

$$\dot{k} = k[g(x) - n], \quad g'(x) > 0, \quad g''(x) < 0, \quad (2.11)$$

where x is the ratio of net investment to the capital stock. Marginal installation costs rise with the rate of investment, which is reflected in the concavity of the installation function in investment. How rapidly costs increase is mirrored by the elasticity of the marginal productivity of investment, σ_x , defined as

$$\sigma_x = - \frac{xg''(x)}{g'(x)}. \quad (2.12)$$

For any given capital stock, the faster the capital stock expands, the more capital goods per additional unit of capital are required.

Firms are equity financed and maximize the present value, V , of their after-tax cash flow (i.e. dividends):

$$V = \int_0^{\infty} [(1 - t_k)(f(k) - w) - (1 - t_I)xk] e^{-(r-n)t} dt, \quad (2.13)$$

where t_k stands for the rate of source-based⁹ tax on capital income (net of depreciation)¹⁰ and t_I represents the subsidy to net investment. Optimization

⁷In the remainder of this paper, unless indicated otherwise, variables are to be understood as dated at time t .

⁸Following Lucas (1967), Summers (1981) models adjustment costs in an alternative way. His formulation, however, leads to similar results for the optimal investment rule.

⁹The corporate income tax is mainly source based. In particular, the corporate tax system in the host country (i.e. the country where the investment occurs) determines the effective corporate tax rate on marginal investment if foreigners finance these investments through portfolio capital flows. Even in the case of direct investments, the corporate tax may be effectively source based, for example, if the residence country has a territorial system of corporate taxation.

¹⁰The tax on capital income is assumed to be assessed on income net of *true* economic depreciation.

of (2.13) subject to (2.11) gives rise to the optimal path for the shadow price of capital, q :

$$\frac{\dot{q}}{q} = r - g(x) - \frac{(1-t_k)f'(k)}{q} + \frac{(1-t_I)x}{q}, \quad (2.14)$$

and the implicit demand function for investment:

$$qg'(x) = (1-t_I). \quad (2.15)$$

2.3. Government

The overlapping generations model causes Ricardian equivalence to fail. Accordingly, the intertemporal equilibrium is affected by how the government distributes the financing burden of the investment-promoting policy across (disconnected) generations. This paper assumes that the government balances its budget at each point in time by levying a common lump-sum tax on every living household.¹¹ This lump-sum tax can also be interpreted as a tax on labor because per capita labor supply is age independent and inelastic. Under the assumption that the government does not issue debt, the after-tax return to human capital (or after-tax labor earnings) amounts to

$$\omega = w + t_k k f'(k) - t_I x k. \quad (2.16)$$

2.4. The model solution

This paper explores the local behavior of the small open economy around the initial steady state by log-linearizing the model around the initial balanced growth path.¹² Unless otherwise indicated, a tilde above a variable stands for the change in this variable relative to its initial steady-state value. As regards the two tax rates, tildes are defined as follows:

$$\tilde{t}_k = \frac{d(1-t_k)}{(1-t_k)} > 0, \quad (2.17)$$

$$\tilde{t}_I = \frac{d(1-t_I)}{1-t_I} < 0. \quad (2.18)$$

In the initial steady state, the investment subsidy is zero ($t_I=0$). The investment-promoting policies examined here are unanticipated and perma-

¹¹Section 9, however, allows for public debt financing.

¹²For similar approaches, see, for example, Judd (1985) and Bovenberg (1986).

ment. They are implemented at $t=0$ and normalized so that they yield the same change in capital intensity. This implies (see section 3)

$$\tilde{t}_k = -\tilde{t}_I > 0. \quad (2.19)$$

The model is solved recursively. First, the log-linearized investment model yields the time paths for the capital stock, the shadow price of capital, investment, and before-tax wages (see appendix A). Combining these solutions with the government budget constraint, one derives the development of after-tax wages (see appendix A), which is used to solve the saving side of the model (see appendix B).

3. The investment system

3.1. Capital accumulation

The investment system yields the following solution for long-run capital deepening (see appendix A):

$$\tilde{k}(\infty) = \left(\frac{\sigma_k}{1 - \alpha_k} \right) (\tilde{t}_k - \tilde{t}_I), \quad (3.1)$$

where α_k represents the share of capital income (net of depreciation) in domestic net income. The effectiveness of the investment-promoting policies in terms of capital accumulation depends importantly on the substitution elasticity between capital and labor in net production, σ_k . Intuitively, a large elasticity reduces the sensitivity of the marginal product of capital with respect to increases in the capital stock. Hence, a substantial expansion of the capital stock is required to reduce the after-tax return to capital to the fixed world rate of return.

During the transition, the capital-labor ratio is given by

$$\tilde{k}(t) = \tilde{k}(\infty)(1 - e^{-ht}). \quad (3.2)$$

The adjustment speed, h , corresponds to the rate of convergence of the capital stock to its new steady-state value and is given by (see appendix A)

$$\frac{h}{r-n} = -\frac{1}{2} + \sqrt{\frac{1}{4} + \frac{(1-t_k)\alpha_k \cdot a_I(1-\alpha_k)}{\sigma_x \cdot \sigma_k \cdot z^2}}, \quad (3.3)$$

where a_I denotes the net investment share in net income and $z = (1-t_k)\alpha_k - a_I \geq 0$ is the share of the after-tax cash flow in domestic net income. A less concave installation function, which reflects more elastic investment, yields a higher adjustment speed. The adjustment speed approaches infinity if adjust-

ment costs are absent (i.e. $\sigma_x = 0$). This case corresponds to perfectly mobile physical capital. The case of a fixed factor, in contrast, is represented by a zero adjustment speed.¹³

The investment system yields solutions for the value of the domestic capital stock and the time path of the after-tax wages. The rest of this section discusses these solutions.

3.2. *The value of the domestic capital stock*

The short-run consequences for the value of the capital stock, $\tilde{q}(0)$, indicate the shifting of the lower tax burden on capital (see appendix A):

$$\tilde{q}(0) = \left(\frac{r-n}{r-n+h} \right) \frac{(1-t_k)\alpha_k}{z} (\tilde{t}_k - \tilde{t}_l) + \tilde{t}_l. \quad (3.4)$$

The owners of the domestic capital stock gain from a lower CIT. The magnitude of this benefit depends on the size of the adjustment speed relative to that of the effective discount rate ($r-n$). The faster after-tax capital earnings fall back to the fixed level in the rest of the world and the less heavily the long-run changes in capital earnings are discounted, the smaller the capitalized gain in capital income becomes. Only with instantaneous relocation of capital to the home country (i.e. $h \rightarrow \infty$) does capital completely shift the lower tax burden to labor [see also, Bovenberg (1986)].

Whether the ITC raises the value of domestic capital depends on the relationship between the speed of capital accumulation and the effective discount rate. In contrast to a lower CIT, the ITC may hurt the owners of the capital stock if the adjustment speed is sufficiently high relative to the discount rate. Intuitively, the ITC initially boosts capital earnings at the expense of lower after-tax wages. As capital accumulates, however, capital earnings fall below, while after-tax wages rise above their initial levels (see below). Discounted capital earnings fall if rapid capital accumulation causes a fast drop in capital earnings and if the lower capital earnings are not discounted at a high rate.

The ITC hurts the owners of the domestic capital stock if low adjustment costs, which are reflected by a low degree of concavity of the installation function, cause rapid capital accumulation. In these circumstances the ITC decreases the value of the domestic capital stock because it reduces the price of new capital goods, which are a close substitute for the installed capital stock if adjustment costs are low [see also Summers (1981)].

¹³Chamley and Wright (1987) examine how an unanticipated tax on a fixed factor affects intergenerational incidence.

3.3. Domestic financial capital

How initial financial wealth of domestic households, $A(0)$, is affected by changes in the value of the domestic capital stock depends on the share of the domestic capital stock initially owned by domestic households, s_k

$$\tilde{A}(0) = s_k z \tilde{q}(0). \quad (3.5)$$

Here \tilde{A} is defined as

$$\tilde{A} = (r - n) \frac{dA}{y}. \quad (3.6)$$

3.4. Labor earnings

The time path of after-tax labor earnings is derived from the investment system under the assumption that the government does not use debt finance (see appendix A):

$$\tilde{\omega}(t) = \tilde{\omega}(0) e^{-ht} + \tilde{\omega}(\infty)(1 - e^{-ht}), \quad (3.7)$$

$$a_\omega \tilde{\omega}(0) = -(1 - t_k) \alpha_k \tilde{t}_k - a_I (-\tilde{t}_I), \quad (3.8)$$

$$a_\omega \tilde{\omega}(\infty) = t_k \alpha_k \left(\frac{\sigma_k}{1 - \alpha_k} \right) (\tilde{t}_k - \tilde{t}_I) + z(-\tilde{t}_I), \quad (3.9)$$

where $a_\omega = (1 - \alpha_k) + t_k \alpha_k$ denotes the share of after-tax labor earnings (including transfers) in domestic net income. Initially, net wages fall on account of the budgetary costs of the investment-promoting policies. The lower CIT reduces after-tax wages more than the ITC does. The reason is that this policy involves larger budgetary costs because it applies a lower tax burden not only to marginal investment but also to existing capital. Following their initial drop, net wages start to rise as the gradual accumulation of capital raises the marginal productivity of labor. In the long run, net wages exceed their initial steady-state value if the initial tax rate on capital is positive ($t_k > 0$). This long-run rise in wages reflects the efficiency gain that is due to a lower intertemporal distortion. Even in the absence of an initial distortion, the ITC causes long-run net wages to rise above their initial steady-state value. In that case, a lower CIT returns long-run wages only to their initial value. Intuitively, in the long run, lower capital income taxes are completely shifted to labor in the form of higher before-tax wages because capital is perfectly mobile in the long run. Therefore, in the new steady state, higher before-tax wages exactly offset the higher lump-sum taxes that are required to finance the budgetary costs of the lower CIT.

Discounting the solution for the path of wages yields the short-run consequences for human wealth of domestic households, $H(0)$:

$$a_\omega \tilde{H}(0) = \left\{ \left(\frac{h}{h+r+\theta} \right) t_k \alpha_k \left(\frac{\sigma_k}{1-\alpha_k} \right) - \left(\frac{r+\theta}{h+r+\theta} \right) (1-t_k) \alpha_k \right\} \\ \times (\tilde{t}_k - \tilde{t}_l) + z(-\tilde{t}_l). \quad (3.10)$$

A lower CIT reduces the value of human capital if the initial CIT is zero. The slower wages rise as a result of sluggish capital accumulation and the higher the discount rate against which wages are discounted, $r+\theta$, the larger the decline in initial human capital becomes. In the presence of an initial tax distortion ($t_k > 0$), a lower CIT may boost human capital if capital deepening happens quickly. Intuitively, capital accumulation increases before-tax wages rapidly enough to compensate workers for higher wage taxes financing the lower CIT, as the lower intertemporal distortion yields overall gains in efficiency.

Compared with a lower CIT, the ITC is more beneficial for human capital. Even in the absence of an initial intertemporal distortion, the ITC still increases the value of human capital if rapid capital accumulation causes the return to human capital to quickly rise above its initial level and if this eventual rise in wages is not discounted at a high rate. Indeed, the human-capital effect mirrors the consequences for the value of domestic capital discussed above. However, it is important to note that wages are discounted at a higher rate than capital earnings are. While the current owners of the capital stock capitalize all future capital earnings, the currently-alive domestic households fail to internalize the wages that accrue to yet-to-be-born generations. Hence, households apply a higher discount rate to wage earnings than to capital earnings. The higher the rate at which new generations emerge, as reflected in the sum of the rates of population growth, n , and probability of death, θ , the larger the gap between the effective discount rates for financial and human capital becomes. In that case, the population is heterogeneous and the time horizons of current generations are short compared with the horizon of the economy at large.

4. The intergenerational distribution

This section first explores how the investment-promoting policies affect the real values of financial and human capital of the generations that are alive when the policy change occurs. It then examines also how these policies impact the real wealth positions of generations that are yet to be born at the time these policies are implemented.

Table 1
Impact effects on real wealth (and consumption) of currently alive.

	Components of total effect		
	Efficiency ^a	Intergenerational distribution ^b	International distribution ^c
<i>Policy instrument:</i>			
$\tilde{t}_k > 0$	+	+ ^d	- ^d
$-\tilde{t}_I > 0$	+	+/- ^e	-/+ ^f

^aThis effect vanishes if t_k , σ_k or h are zero. It increases with t_k , σ_k and h .

^bThis effect vanishes if $(n+\theta)$ or s_k are zero. It increases with $(n+\theta)$ and s_k .

^cThis effect vanishes if s_k is one. It decreases with s_k .

^dThis effect is large in absolute value if h is small.

^e+ if h is small; - if h is large.

^f- if h is small; + if h is large.

4.1. The currently alive

The effect on real wealth of the generations that are alive when the investment-promoting policies are implemented, $\tilde{W}(0)$,¹⁴ is found by combining the effects on human and financial capital owned by domestic households [substitute expressions (3.5) and (3.10) into expression (B.12) in appendix B]:

$$\begin{aligned}
 \left(\frac{r+\theta}{\Delta}\right) a_c \tilde{W}(0) = & \left(\frac{h}{h+r+\theta}\right) t_k \alpha_k \left(\frac{\sigma_k}{1-\alpha_k}\right) (\tilde{t}_k - \tilde{t}_I) + s_k(n+\theta) \\
 & \times \left\{ \left[\frac{r+\theta}{r+\theta+h} \right] \frac{(1-t_k)\alpha_k}{(r-n+h)} (\tilde{t}_k - \tilde{t}_I) - \left(\frac{z}{r-n}\right) (-\tilde{t}_I) \right\} \\
 & + (1-s_k) \left\{ - \left[\frac{r+\theta}{r+\theta+h} \right] (1-t_k)\alpha_k (\tilde{t}_k - \tilde{t}_I) + z(-\tilde{t}_I) \right\}, \quad (4.1)
 \end{aligned}$$

where a_c stands for the share of consumption in domestic net income. This expression is interpreted below by distinguishing between the case in which domestic households own the entire domestic capital stock (i.e. $s_k=1$) and the case in which foreigners own the entire stock (i.e. $s_k=0$). If foreigners initially own only a part of the domestic capital stock, the domestic welfare effect is given by the weighted average of the two cases examined here. Table 1 summarizes the discussion below.

¹⁴This effect on real wealth provides a measure for the average consequences for the welfare of the currently alive. How the policies affect the welfare of currently-alive generations with different ages depends on how the ownership of the domestic capital stock is distributed across different age groups when the policy shock occurs.

4.1.1. *Without foreign ownership*

A lower CIT benefits current generations. The first term on the right-hand side of (4.1) stands for a pure efficiency gain, which is due to a lower intertemporal distortion. This effect becomes large if the substitution elasticity between labor and capital is large and the installation function is not very concave (and, therefore, the adjustment speed is high). Under these circumstances, capital accumulation is sensitive to the intertemporal distortion. A reduction in this distortion, therefore, yields a substantial gain in efficiency.

The terms on the second line in (4.1) represent the intergenerational distributional effect. Current generations gain from a lower CIT because this policy benefits capital at the expense of labor. Whereas current generations capitalize higher capital earnings, they do not fully internalize the fall in labor earnings because lower wages are in part absorbed by future generations.

Current generations benefit most from the intergenerational distributional effect if the rate of birth, $n + \theta$, is high and capital accumulation occurs only slowly (i.e. h is small). A low speed of capital accumulation causes capital earnings to fall only slowly after their initial rise, thereby raising discounted capital earnings, which accrue to the currently alive. A high birth rate implies that the currently alive bear only a small part of the lower return to human capital. Hence, while a high adjustment speed and a low birth rate raise the impact on efficiency, they reduce the effect on the intergenerational distribution. Intuitively, elastic behavior, which is reflected in a high speed of adjustment, dampens distributional impacts but raises efficiency effects. Furthermore, a low birth rate implies that the population is homogeneous and that current generations internalize a large part of changes in overall welfare. Accordingly, the welfare of current generations depends more on overall efficiency and less on the distribution of labor income over time. Note that the intergenerational distributional effect originates in the interaction of, on the one hand, adjustment costs in investment and, on the other hand, (disconnected) overlapping generations. This effect would not occur in a model with either a representative agent (i.e. $\theta + n = 0$) or perfectly mobile physical capital (i.e. $h \rightarrow \infty$).

Whether the ITC benefits the currently alive depends on the parameters of the model. The efficiency effect, which is represented by the first term in (4.1), dominates if the birth rate is small and the initial distortion is large due to the combination of a high initial tax rate on capital income and a high substitution elasticity in production. In that case, the ITC boosts real wealth of the current generations. If the birth rate is high or the initial distortion is small, however, the intergenerational distributional effect determines the welfare of these generations. The sign of the intergenerational effect of the ITC depends importantly on the speed of capital accumulation. Whereas

current generations lose from the ITC if the adjustment speed is high, they benefit if this speed is low. Intuitively, a low adjustment speed boosts capital earnings, which are fully capitalized by current generations. At the same time, it implies lower labor earnings, which are in part shifted to future generations, because a lower adjustment speed slows down the rate at which capital accumulation raises the return to human capital.

Compared with a lower CIT, the ITC is less beneficial for current generations. The currently alive are indifferent between the two investment-promoting policies only if they fully internalize the welfare of future generations (i.e. $n + \theta = 0$).

4.1.2. *With foreign ownership*

Foreign ownership does not affect the efficiency gains from capital accumulation that accrue to domestic households. The reason is that immobile labor rather than capital absorbs these gains in the form of lower tax payments. However, foreign ownership fundamentally changes the economic implications of policies that alter the distribution between labor and capital. Without foreign ownership, current generations at home benefit from policies that distribute wealth away from labor toward capital, such as a lower CIT. If foreigners own the domestic capital stock, however, the higher capital earnings accrue to foreign rather than domestic households.

Whereas *without* foreign ownership domestic current generations gain from a lower CIT, *with* foreign ownership they lose as long as the efficiency effect is small. Furthermore, in the absence of foreign ownership, a low speed of capital accumulation benefits these generations because it boosts discounted capital earnings by slowing down the fall in capital earnings. In the presence of foreign ownership, in contrast, they suffer from slow capital accumulation. The reason is that foreigners rather than current generations at home absorb the changes in capital earnings if they own the entire domestic capital stock. Consequently, policies affect domestic generations only through changes in net wages. Hence, the slower wages rise following their initial drop, the larger the loss in welfare experienced by domestic households.

In the absence of foreign ownership, domestic households that are currently alive lose from the ITC if the speed of capital accumulation is high and the efficiency effect is small. If, in these circumstances, foreigners own the domestic capital stock, in contrast, current generations at home may gain. If capital accumulation happens rapidly, the ITC reduces the value of the domestic capital stock while it raises discounted wages (i.e. the value of human capital) of the currently alive as long as the birth rate is not too high. Accordingly, whether or not domestic current households gain from the ITC depends on their initial ownership share of the domestic capital stock. If they initially own the entire stock they absorb all windfall losses and therefore, they lose. However, if they do own a smaller share, they lose less. If they do

not own any part of the domestic capital stock, the ITC amounts to an implicit tax on foreigners and domestic households may gain due to the rise in the value of human capital.

4.2. Future generations

The time path for after-tax labor earnings is the only determinant of the effects on welfare of future generations, which are not yet born at the time of the policy shock. These generations depend entirely on wage income because they begin their lives without any financial wealth. The consequences for (human) wealth of the generation born at time $t \geq 0$ are given by

$$\tilde{H}(t) = \tilde{H}(0)e^{-ht} + \tilde{\omega}(\infty)(1 - e^{-ht}). \quad (4.2)$$

The initial change in human wealth, $\tilde{H}(0)$, corresponds to the effect on the welfare of the generation that is born at the time of the policy shock. The welfare consequences for generations that are born when the economy approaches its new balanced growth path are given by the long-run effect on net wages.

If there is no initial intertemporal distortion, a lower CIT hurts future generations by reducing net wages. The generations that are born soon after the policy shock suffer the heaviest because labor earnings decline most immediately after the CIT is reduced. Compared with a lower CIT, the ITC is less harmful to future generations. It benefits future generations that are born when the economy approaches its new steady state and may even benefit all generations born after the ITC takes effect. This is the case if a high adjustment speed (relative to the discount rate $r + \theta$) causes the ITC to boost initial human capital.

5. Consumption

This section discusses how economy-wide consumption develops after the two alternative investment-promoting policies are implemented. Table 2 contains a summary of the discussion. Aggregate consumption is given by (see appendix B)

$$\begin{aligned} \tilde{C}(t) = & \tilde{C}(0)e^{-h^*t} + \tilde{C}(\infty)(1 - e^{-h^*t}) \\ & + h^* \left(\frac{r + \theta}{r + \theta + h} \right) (\tilde{\omega}(0) - \tilde{\omega}(\infty)) \left(\frac{e^{-ht} - e^{-h^*t}}{h^* - h} \right), \end{aligned} \quad (5.1)$$

Table 2
Effects on consumption.

	$\tilde{C}(0)$	$\dot{\tilde{C}}(0)$	$\dot{\tilde{C}}(\infty)^a$	$\tilde{C}(\infty)$
<i>Component:</i>				
Efficiency ^b	+	+/- ^c	+ ^d	+
$\tilde{t}_k > 0$:				
Intergenerational distribution ($s_k = 1$) ^e	+	-	+	0
International distribution ($s_k = 0$)	-	-/+ ^f	+	0
$-\tilde{t}_l > 0$:				
Intergenerational distribution ($s_k = 1$) ^e	+/- ^g	-/+ ^h	+	+
International distribution ($s_k = 0$)	-/+ ^h	+/- ⁱ	+	+

^a $\dot{\tilde{C}}(n)$ for n very large.

^b This effect is the same for both investment-promoting policies. It dominates if h , t_k and σ_k are large or $(n + \theta)$ is small and $s_k = 1$.

^c + if $r > \delta$; - if $r < \delta$.

^d Unless $r < \delta$, h is large, and $n + \theta$ is small.

^e This effect dominates if $(n + \theta)$ is large.

^f - if $r > \delta$; + if $r < \delta$.

^g + if h is small; - if h is large.

^h - if h is small; + if h is large.

ⁱ - if $r > \delta$ and h small or if $r < \delta$ and h large; + if $r > \delta$ and h large or if $r < \delta$ and h small.

$$\tilde{C}(0) = \tilde{W}(0), \quad (5.2)$$

$$\tilde{C}(\infty) = \tilde{\omega}(\infty), \quad (5.3)$$

$$h^* = \Delta - (r - n) = (n + \theta) - \left(\frac{r - \delta}{\sigma} \right). \quad (5.4)$$

Just as in subsection 4.1, this section examines, in turn, the cases without and with initial foreign ownership.

5.1. Without foreign ownership

If foreigners do not own any domestic capital in the initial steady state, the development of domestic consumption depends on the relative magnitudes of, on the one hand, the gain in overall efficiency and, on the other hand, the change in the intergenerational distribution. If the first effect

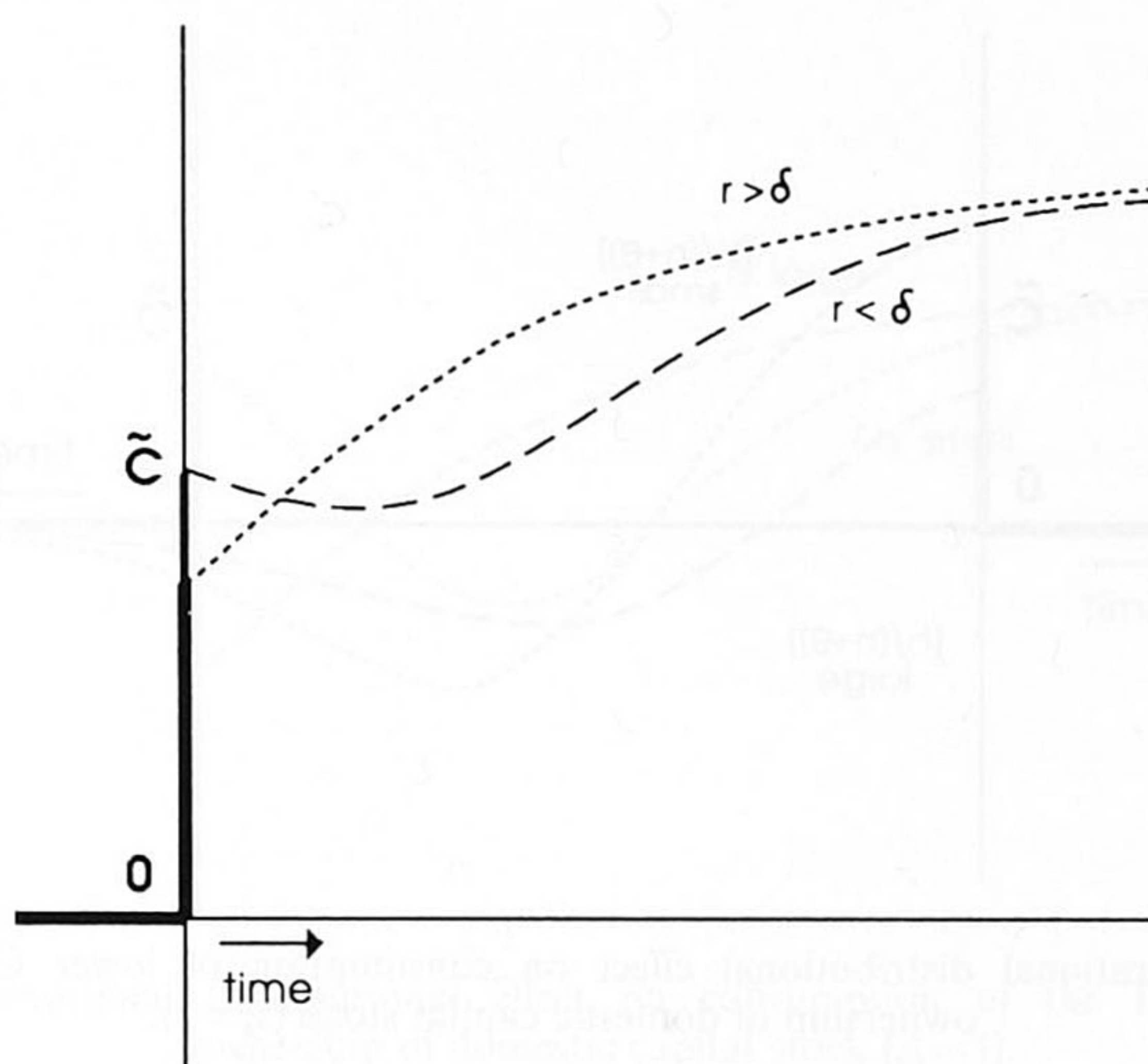


Fig. 1. Efficiency effect and consumption.

dominates,¹⁵ the two investment-promoting policies yield similar consumption paths. If r exceeds δ , consumption rises monotonically after its initial rise until it reaches its new steady-state value (see fig. 1). If r is smaller than δ , the time path of consumption is non-monotonic: consumption falls after its initial rise before it increases again near the new steady state. Intuitively, the development of consumption at each point in time depends on the relationship between the welfare of the older generations and that of the generations who are newly born. Economy-wide consumption rises if and only if newly born generations are wealthier than the generations that have already been alive. If δ exceeds r , the currently alive own negative financial wealth and, therefore, are more dependent on labor earnings than newly born generations are. Hence, the newly born benefit relatively less from the rise in human wealth due to the overall efficiency gain and, therefore, aggregate consumption falls. Eventually, consumption rises again as the population share of households who owned negative financial wealth at the time of the policy shock drops off and the development of consumption depends on the comparison of wealth positions of generations born after the policy shock. Since wages are rising, the human wealth of the newly born exceeds that of

¹⁵The efficiency impact dominates if $t_k \sigma_k$ and h are large compared with the birth rate, $n + \theta$. In that case, the first term on the right-hand side of (4.1) determines the effect of the term $\tilde{C}(0) = \tilde{W}(0)$ in expression (5.1) for the time path of consumption. The impacts on the terms with $\tilde{C}(\infty) = \tilde{\omega}(\infty)$ and $(\tilde{\omega}(0) - \tilde{\omega}(\infty))$ are dominated by the first term on the right-hand side of (3.9).

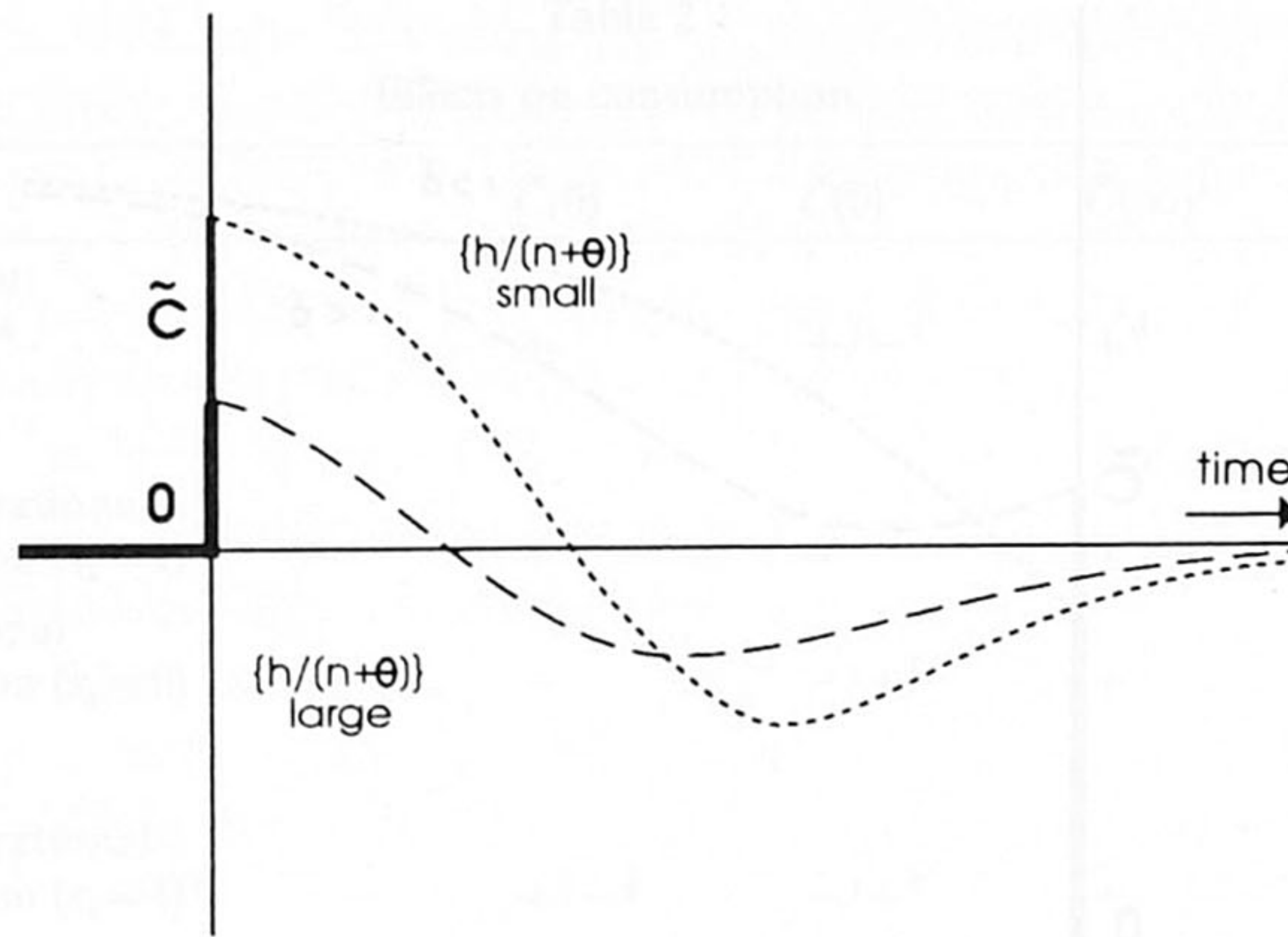


Fig. 2. Intergenerational distributional effect on consumption of lower CIT with domestic ownership of domestic capital stock ($s_k = 1$).

the older generations (who are themselves mostly born after the policy shock) and the consumption, therefore, rises.

If the second (intergenerational distribution) effect dominates,¹⁶ the two policies generate different consumption paths. In particular, the time path of consumption is non-monotonic after the lower CIT is implemented (fig. 2). Initially, consumption rises on account of the improvement in the wealth position of the currently alive. Following the initial rise, however, consumption starts to fall as the population share rises of young generations whose real (human) wealth declines because they had not yet been born at the time the policy shock and, therefore, did not benefit from higher capital earnings. Hence, the higher is the rate of birth, $n + \theta$, the faster consumption falls after its initial rise. If the efficiency effect is small, consumption even falls below its initial steady-state value, as the generations who were alive when the CIT was reduced die off. Eventually, however, consumption starts to rise again. If the initial tax rate and, therefore, the (first-order) efficiency effect is zero, consumption returns to its initial steady-state value. The eventual rise in consumption is due to the rising trend of wages. Near the new steady state, almost all living generations have been born after the CIT was reduced. Therefore, changes in human wealth are the major determinants of the relative wealth positions of the older and newly born generations. Hence, those who are born near the new steady state are better off than the older

¹⁶The intergenerational distribution effect dominates if the birth rate, $n + \theta$, is large relative to $t_k \sigma_k$. In that case [and without foreign ownership (i.e. $s_k = 1$)], the second terms on the right-hand sides of (4.1) and (3.9) determine the effects on, respectively, $\tilde{C}(0) = \tilde{W}(0)$ and $\tilde{C}(\infty) = \tilde{\omega}(\infty)$.

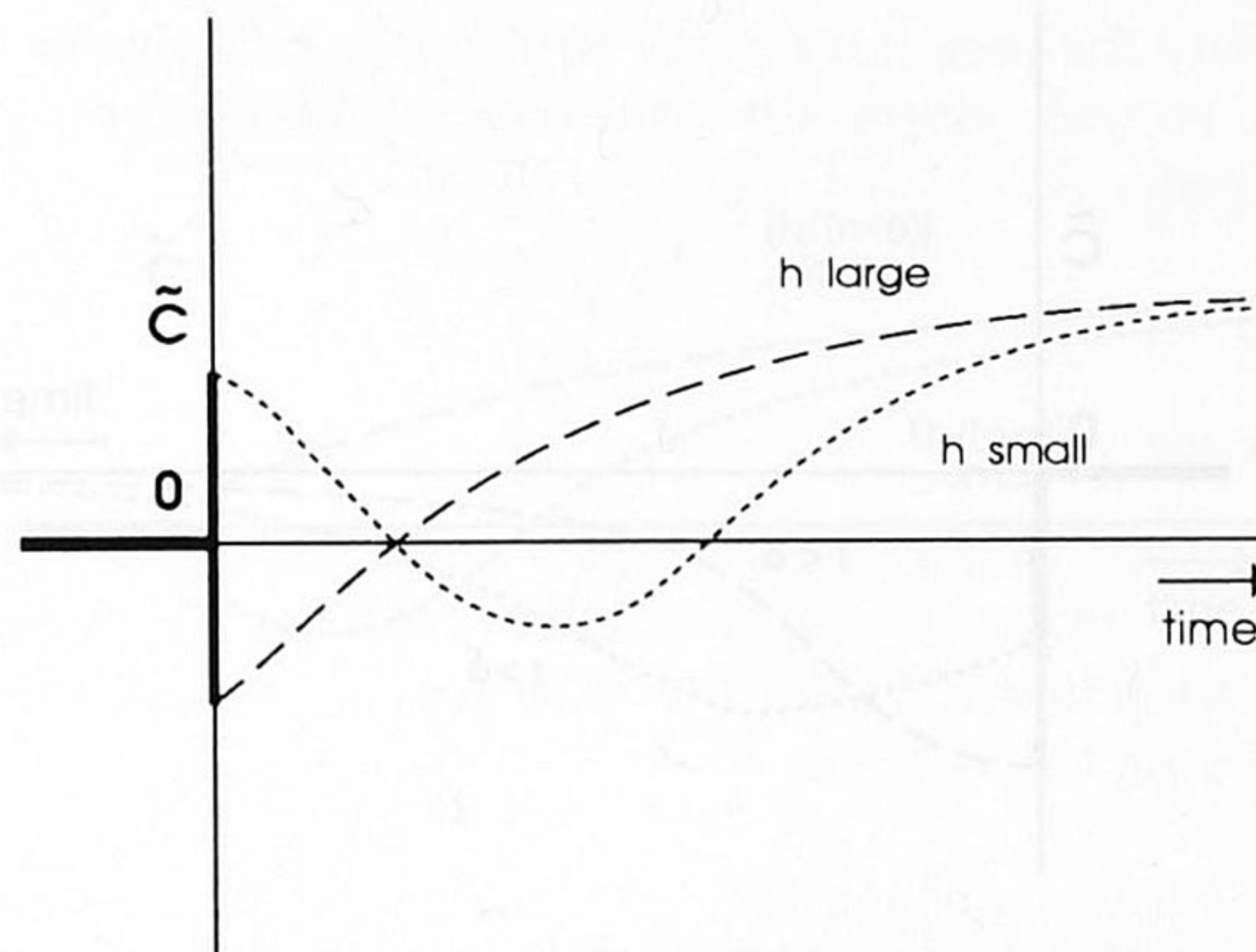


Fig. 3. Intergenerational distributional effect on consumption of the ITC with domestic ownership of domestic capital stock ($s_k = 1$).

generations because the newly born benefit from higher human wealth, as wages are rising over time.

Substantial intergenerational effects due to a slow adjustment speed and a high birth rate strengthen the fluctuations in consumption. If the adjustment speed rises and the birth rate falls, consumption flattens out (fig. 2). Consumption stays constant at its initial steady-state level if the initial tax rate is zero (i.e. no efficiency effect) and the ratio $[h/(n+\theta)]$ approaches infinity.

In the absence of efficiency effects (i.e. $t_k \sigma_k = 0$), the ITC produces the largest swings in consumption if new generations enter at a high speed and, therefore, intergenerational distributional effects are large. The adjustment speed determines the monotonicity of the consumption path (fig. 3). If capital accumulation occurs slowly, consumption develops non-monotonically as the time profile of the consumption path resembles that after the implementation of a lower CIT. The reason is that under these circumstances both investment-promoting policies cause the value of financial capital to rise relative to that of human capital. Consequently, older generations who own the capital stock gain at the expense of those who are born immediately after the policy shock and who, therefore, depend on human capital. Consequently, consumption falls after an initial rise. Eventually, however, consumption starts to rise for the reasons discussed above for the case of a reduction of the CIT. In contrast to a lower CIT, however, the ITC causes long-run consumption to rise above its initial level – even if the efficiency effect is zero.

If capital accumulation occurs rapidly, the ITC yields a different time

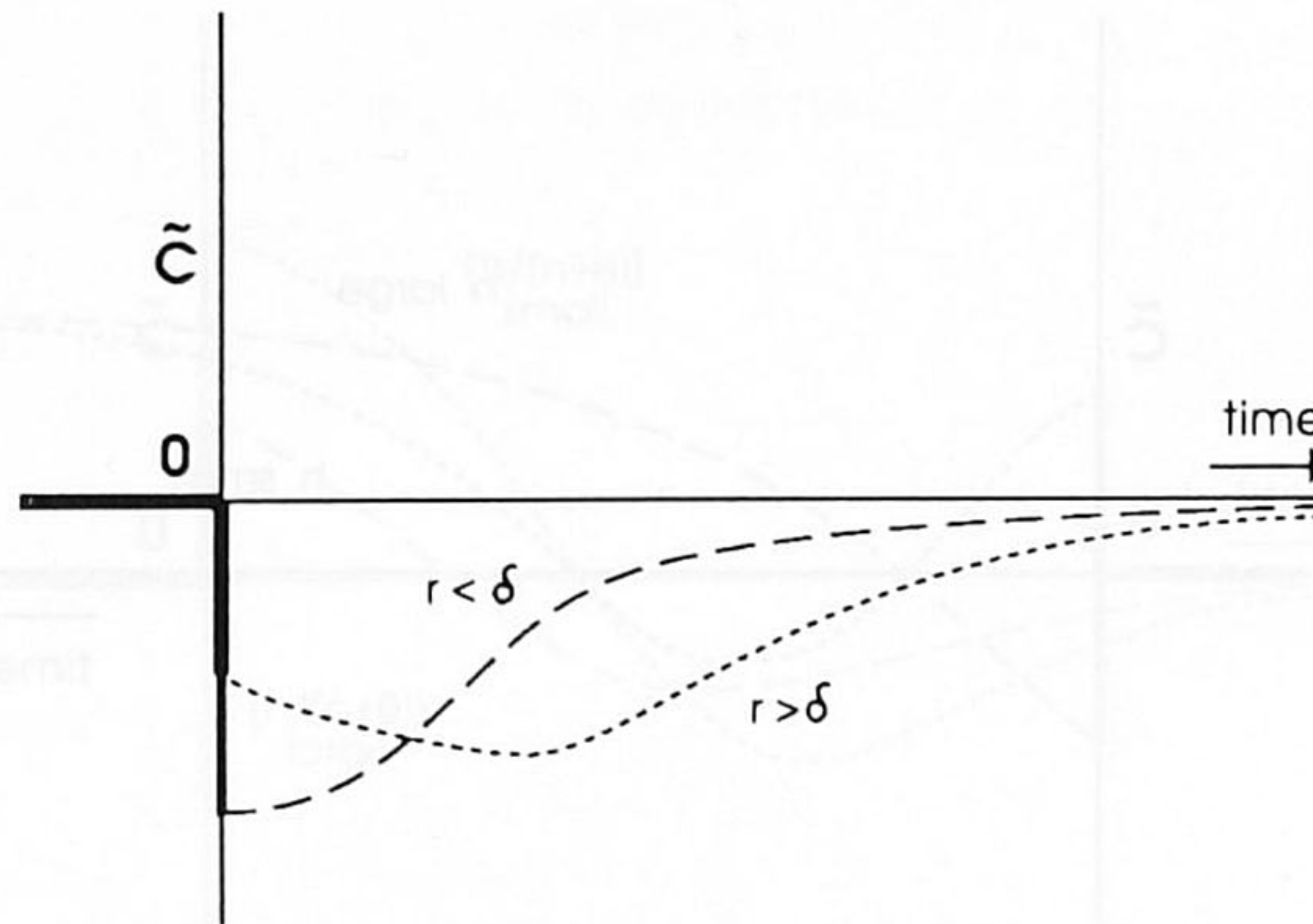


Fig. 4. Effect on consumption of lower CIT with foreign ownership of domestic capital stock ($s_k = 0$; $t_k = 0$).

profile of the consumption path compared with a lower CIT. In particular, the ITC causes aggregate consumption to rise monotonically following an initial fall (fig. 3).¹⁷ Intuitively, the younger a generation is, the better off it is in terms of welfare. Those who are born after the ITC is implemented gain relative to those who were alive at the time policy changed because these younger generations do not suffer a windfall loss on account of a fall in the value of the domestic capital stock. Moreover, the later one is born, the more one benefits from the rising trend in wages.

5.2. *With foreign ownership*

The shape of the consumption path with foreign ownership depends on the relative sizes of, on the one hand, the gain in overall efficiency, and, on the other hand, the international distributional effect on account of the change in the distribution between capital and labor. If the efficiency effect dominates the distributional effect, the consumption path is similar to that in the case without foreign ownership. Therefore, the rest of this section assumes that the initial tax rate is zero so that the international distributional effect dominates.¹⁸

The time path for consumption following the implementation of a lower CIT is non-monotonic if domestic households hold positive financial wealth (i.e. r exceeds δ) (see fig. 4). The reason is that those who are born at or

¹⁷If the initial tax rate is positive and horizons are long, initial consumption may rise as the efficiency effect is likely to dominate the distributional effect.

¹⁸In this case, the third term on the right-hand side of (4.1) determines the initial effect on consumption, $\tilde{C}(0) = \tilde{W}(0)$.

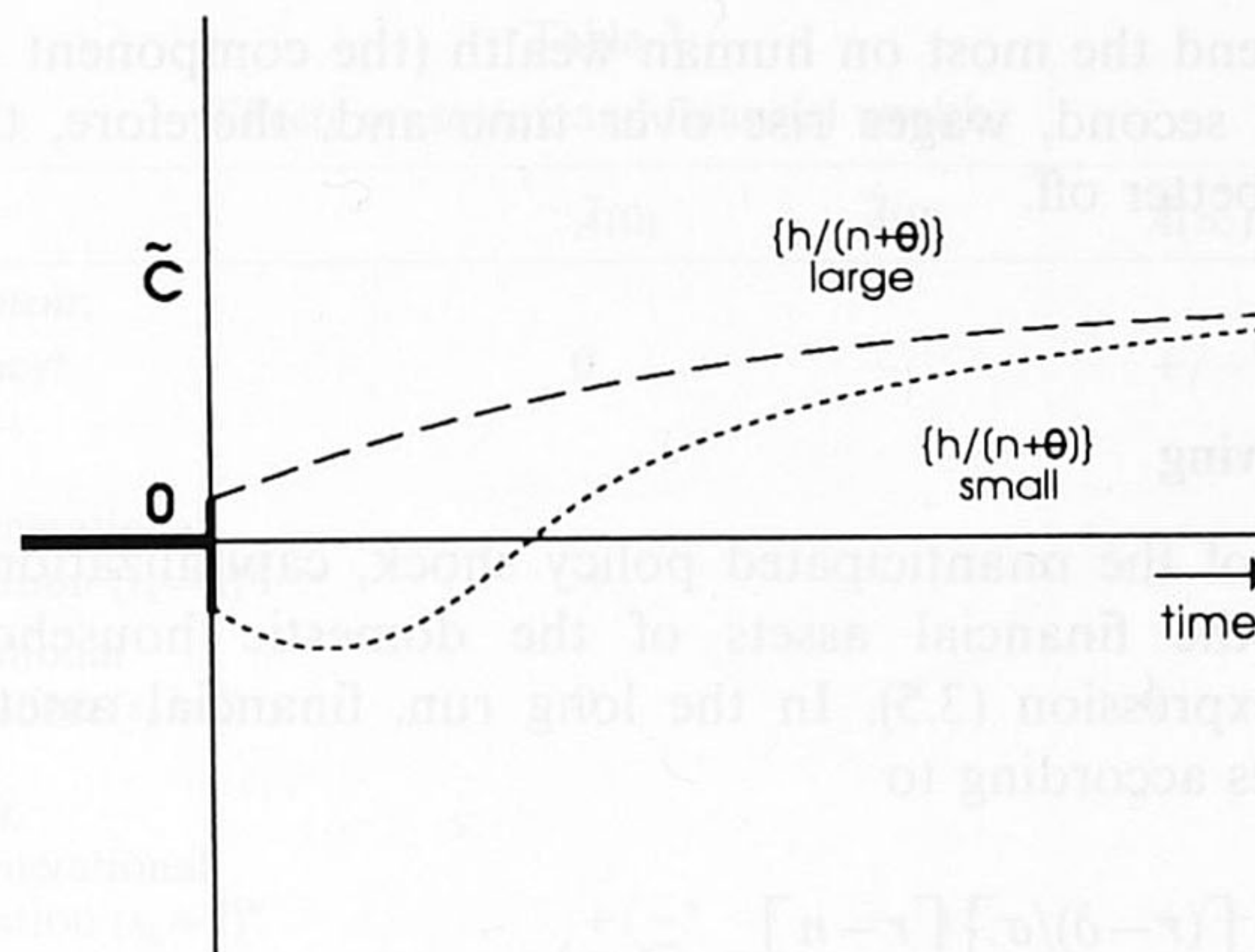


Fig. 5. Effect on consumption of the ITC with foreign ownership of domestic capital stock ($s_k = 0$; $r > \delta$).

immediately after the policy shock depend more on human wealth than do the older generations who have accumulated financial wealth. Accordingly, the newly born are hurt most by the decline in real wages. Therefore, aggregate consumption falls as the newly born are worse off than the older generations. Eventually, consumption starts to rise when the population share of those born after the policy change rises and when, therefore, the rising trend in wages determines the relative wealth positions of the newly born compared with older generations. A lower CIT causes consumption to rise monotonically following its initial fall only if domestic households own negative financial wealth ($r < \delta$) (see fig. 4). In that case, the share of human wealth in total wealth is larger for the current generations than for newly born generations. Hence, current generations suffer more from declining wages than those who are born at or immediately after the policy shock. Consequently, aggregate consumption rises after the initial fall.

The ITC yields similar consumption paths as a lower CIT does if the capital accumulation occurs slowly and the birth rate is high (see fig. 5). In this case, domestic current generations suffer from an initial fall in wages because capital accumulation occurs too late to benefit them in the form of higher wages. Just as in the case of a lower CIT, the ITC causes consumption to rise monotonically only if domestic households hold negative financial wealth (see above). If the adjustment speed is high and the birth rate is small, discounted wages of domestic households rise and consumption increases initially. Consumption continues to rise monotonically if and only if households hold positive financial wealth (see fig. 5). If financial wealth is positive, young generations gain more than the older ones for two reasons.

First, they depend the most on human wealth (the component of wealth that rises in value); second, wages rise over time and, therefore, those who are born later are better off.

6. Domestic saving

At the time of the unanticipated policy shock, capitalization effects cause the value of the financial assets of the domestic households to jump according to expression (3.5). In the long run, financial assets are directly related to wages according to

$$\tilde{A}(\infty) = \left[\frac{(r-\delta)/\sigma}{r+\theta} \right] \left[\frac{r-n}{h^*} \right] a_\omega \tilde{\omega}(\infty). \quad (6.1)$$

During the transition, financial assets are given by (appendix B)

$$\begin{aligned} \tilde{A}(t) = & \tilde{A}(0) e^{-h^* t} + \tilde{A}(\infty)(1 - e^{-h^* t}) \\ & + \left(\frac{h + [(r-\delta)/\sigma]}{h+r+\theta} \right) a_\omega (r-n) [\tilde{\omega}(0) - \tilde{\omega}(\infty)] \\ & \times \left(\frac{e^{-ht} - e^{-h^* t}}{h^* - h} \right). \end{aligned} \quad (6.2)$$

This expression, together with (3.4), (3.5), (3.8), (3.9), (5.4) and (6.1), yields the response of domestic saving when the investment-promoting policies are implemented:¹⁹

$$\begin{aligned} \frac{\dot{\tilde{A}}(0)}{r-n} = & - \left(\frac{\Delta}{r+\theta} \right) \left(\frac{h}{h+r+\theta} \right) t_k \alpha_k \frac{\sigma_k}{1-\alpha_k} (\tilde{t}_k - \tilde{t}_l) \\ & + s_k \left\{ - \left(\frac{h}{h+r-n} + \frac{\Delta(n+\theta)}{(r+\theta+h)(r-n+h)} \right) \right. \\ & \left. \times (1-t_k) \alpha_k (\tilde{t}_k - \tilde{t}_l) + \frac{\Delta(n+\theta)}{(r+\theta)(r-n)} z(-\tilde{t}_l) \right\} \end{aligned}$$

¹⁹The combination of a tilde and a dot stands for the policy-induced change in the rate of growth.

Table 3
Effects on saving and financial wealth.

Component:	$\tilde{A}(0)$	$\dot{\tilde{A}}(0)$	$\tilde{A}(\infty)$
Efficiency ^a	0	—	+/- ^b
$\tilde{t}_k > 0$:			
Intergenerational distribution ($s_k = 1$) ^c	+	—	0
International distribution ($s_k = 0$)	0	— ^d	0
$-\tilde{t}_l > 0$:			
Intergenerational distribution ($s_k = 1$) ^c	+/- ^e	-/+ ^f	+/- ^b
International distribution ($s_k = 0$)	0	— ^d	+/- ^b

^aThis effect is the same for both investment-promoting policies. It dominates if h , t_k and σ_k are large.

^b+ if $r > \delta$; — if $r < \delta$.

^cThis effect dominates if $(n + \theta)$ is large.

^dUnless $r < \delta$ and h is (very) small.

^e— if h is large. + if h is small.

^f+ if h and $(n + \theta)$ are large; — otherwise.

$$\begin{aligned}
 & + (1 - s_k) \left\{ - \left(\frac{h + [(r - \delta)/\sigma]}{h + r + \theta} \right) (1 - t_k) \alpha_k (\tilde{t}_k - \tilde{t}_l) \right. \\
 & \quad \left. + \left(\frac{(r - \delta)/\sigma}{r + \theta} \right) z(-\tilde{t}_l) \right\}. \quad (6.3)
 \end{aligned}$$

This section explores the response of domestic saving by interpreting the time path of financial assets. It first examines the case without initial foreign ownership of domestic capital. It then turns to the case in which foreigners own the entire domestic capital stock when the policy shock occurs. Table 3 provides a summary of the various effects identified in this section.

6.1. Without foreign ownership

A lower CIT unambiguously reduces saving at the time the policy shock occurs because expression (6.3) consists of three non-positive parts. The first term on the right-hand side of (6.3) involves the long-run rise in income that is due to the gain in intertemporal efficiency. If the initial tax rate on capital is positive, households initially save less because they smooth their consump-

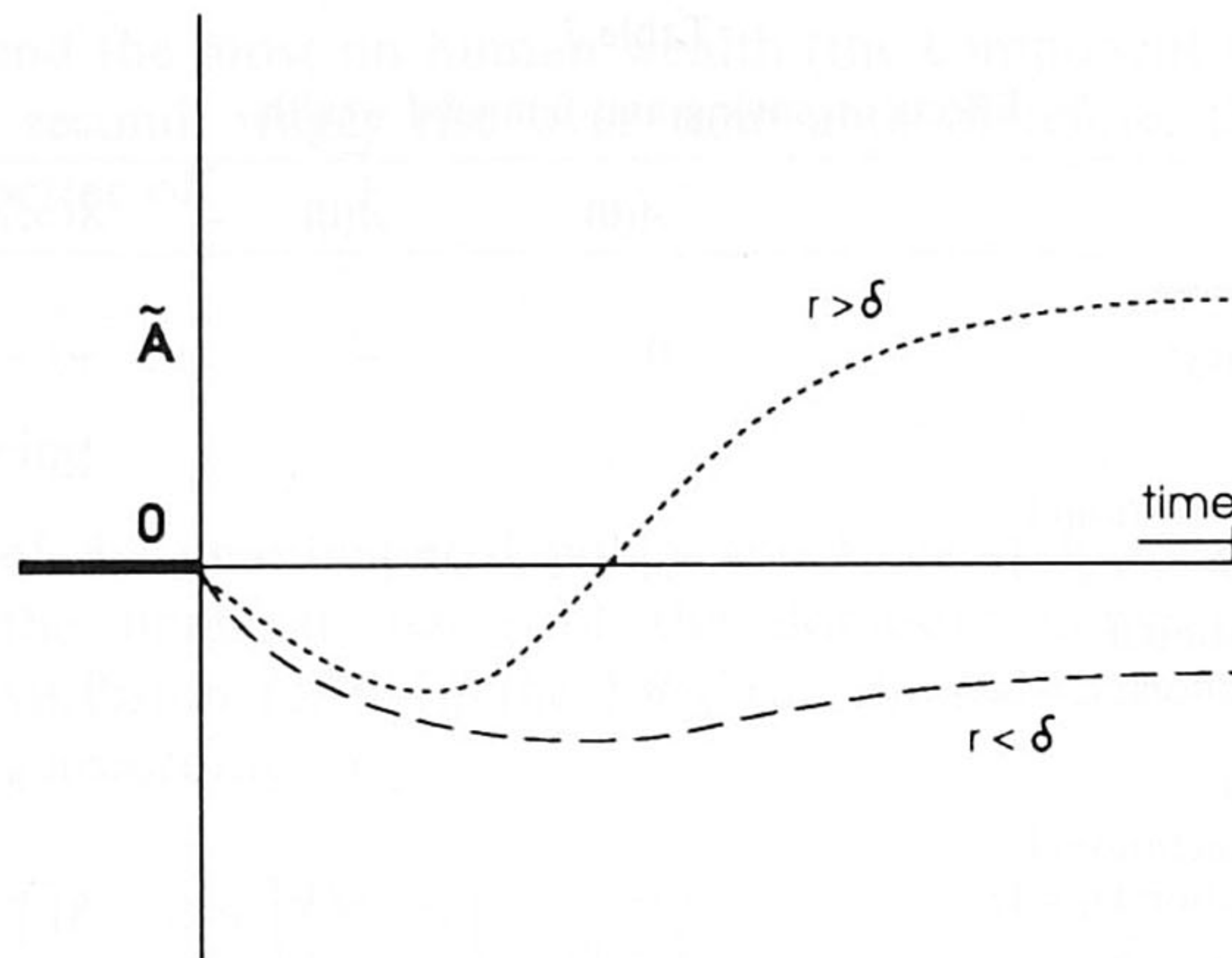


Fig. 6. Efficiency effect and financial assets.

tion intertemporally in anticipation of the rise in after-tax income that corresponds to the efficiency gain produced by a larger capital stock. The more capital accumulation occurs within the horizons of the currently alive (i.e. the speed of capital accumulation, h , is large relative to the birth rate, $n + \theta$), the larger this negative effect on initial saving becomes.

If the interest rate exceeds the discount rate, the efficiency effect raises financial assets in the long run as it increases after-tax wages in the new steady state [see expression (6.1)]. Consequently, the short-run decumulation of financial assets on account of the efficiency effect is only temporary and the path for financial assets is non-monotonic (see fig. 6). The reason is twofold. First, if the economy approaches the new steady state, the rate at which aggregate income rises on account of the expansion of the capital stock falls. Hence, domestic households anticipate smaller gains in future incomes and, therefore, build up their financial assets again. The second factor behind the eventual rise of financial assets is that younger generations benefit the most from the gains in intertemporal efficiency. If the interest rate exceeds the discount rate, financial wealth rises with age. Accordingly, younger generations depend more on human wealth than the older generations do and they, therefore, gain most from the gains in intertemporal efficiency, which are reflected in rising after-tax wages.

Also the first term on the second line of (6.3) involves consumption-smoothing. Households reduce their financial assets as they expect capital accumulation to raise wages by boosting the marginal productivity of labor. Finally, the second term on the second line of (6.3) stands for the intergenerational distribution effect in favor of current generations. Current consumption exceeds current income because current generations base their

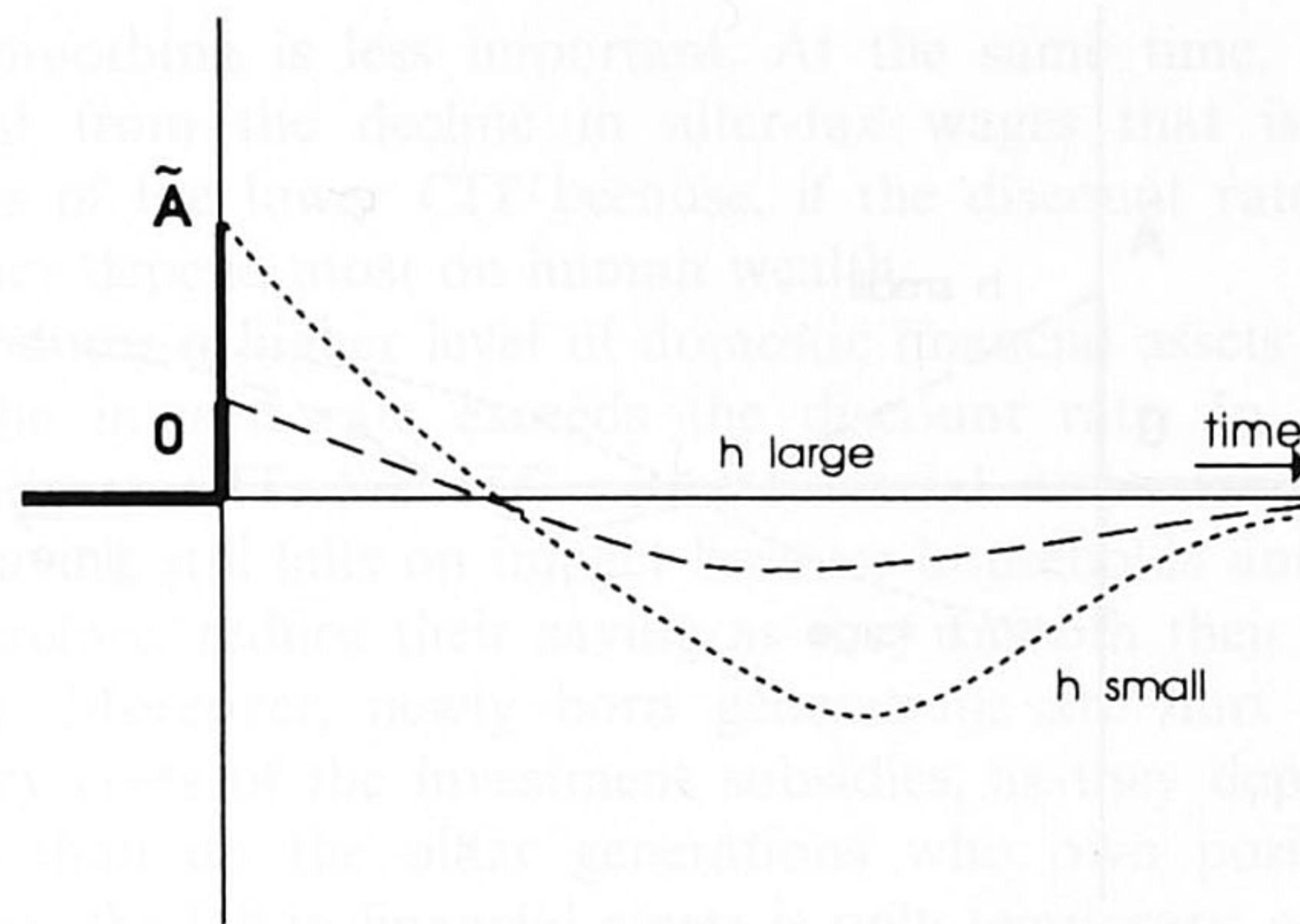


Fig. 7. Intergenerational distributional effect on financial assets of lower CIT with domestic ownership of domestic capital stock ($s_k = 1$; $t_k = 0$).

consumption decisions on their own permanent income, which exceeds that of the economy at large.

The relative magnitudes of the second and third effects depend on the ratio of the adjustment speed and the birth rate. Consumption-smoothing is most important in determining initial saving if capital accumulation occurs rapidly and the population is homogeneous. If, in contrast, most capital accumulation happens beyond the horizons of the currently alive, the saving impact of the intergenerational redistribution dominates.

If the initial tax rate is zero, financial assets return to their initial value in the long run after capitalization effects caused an initial increase. Both consumption-smoothing and the intergenerational distribution effect are likely to produce a non-monotonic decline in financial assets (see fig. 7). In particular, consumption-smoothing falls back as the rate at which wages rise falls (see above). Furthermore, the intergenerational distributional effect on saving reflects the non-monotonic consumption path discussed in section 5.

Compared with a lower CIT, the ITC yields a stronger performance of domestic saving. Whereas the two investment-promoting policies share the two consumption-smoothing components in expression (6.3), they yield a different term for the saving effect of changes in the intergenerational distribution. In contrast to a lower CIT, the ITC may boost saving. This happens if the ITC benefits future generations at the expense of the currently alive and if this intergenerational distributional effect dominates the two consumption-smoothing terms discussed above. This is the case if capital accumulation occurs rapidly and if a high birth rate indicates that the population is heterogeneous. In these circumstances, consumption-smoothing is less important because horizons are short. At the same time, the

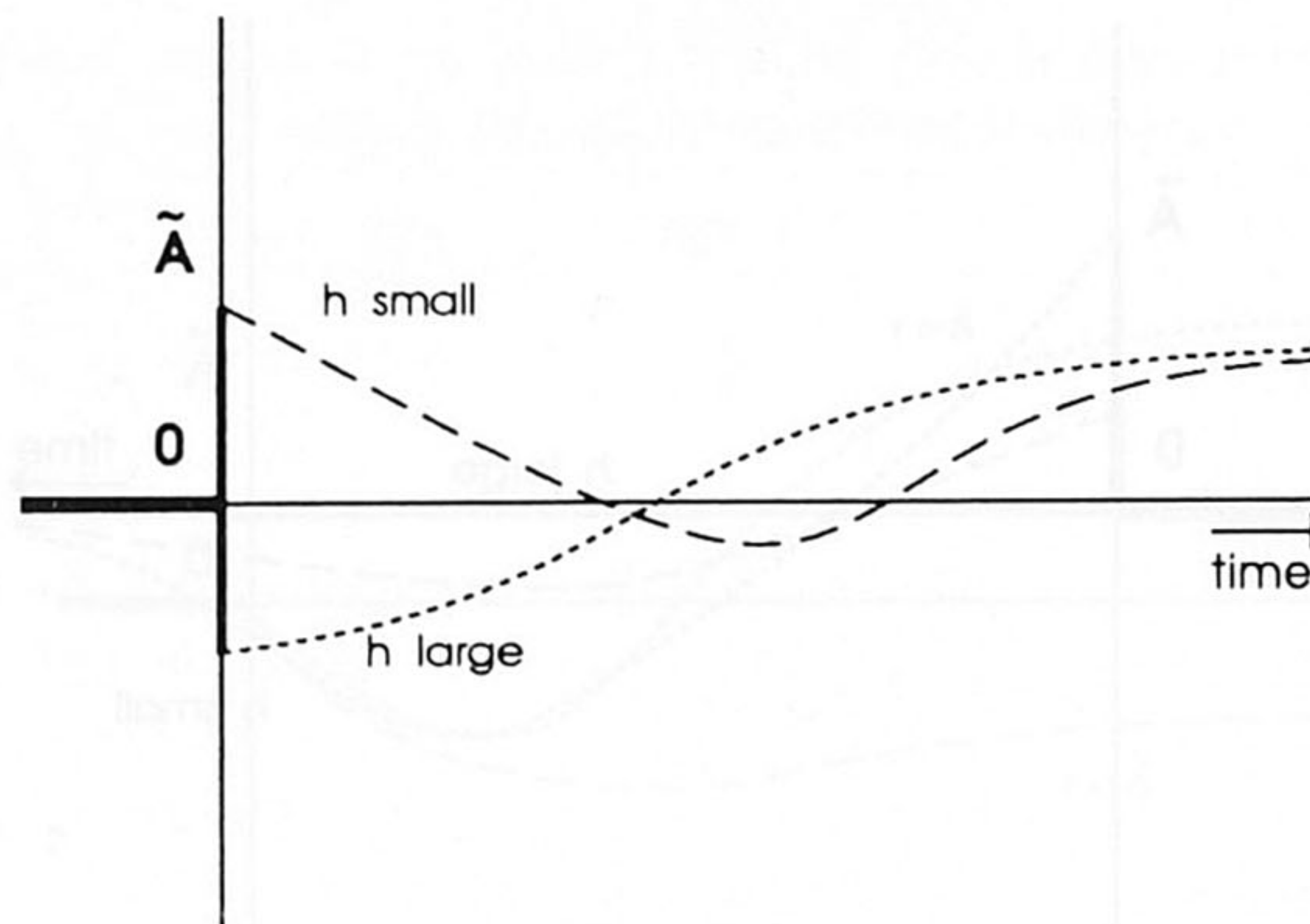


Fig. 8. Intergenerational distributional effect on financial assets of ITC with domestic ownership of domestic capital stock ($s_k = 1$; $r > \delta$).

intergenerational distributional effect is large and boosts saving, as current generations experience a windfall loss on account of a decline in the value of physical capital.

If the interest rate exceeds the discount rate and the ITC causes saving to rise on impact, financial assets continue to rise monotonically after an initial fall and rise above their initial value in the new steady state (see fig. 8). If saving falls on impact, financial assets are likely to develop non-monotonically, as saving rises near the steady state for the reasons discussed in the lower CIT case.

6.2. *With foreign ownership*

The degree of foreign ownership does not affect the saving effect of a gain in intertemporal efficiency. Hence, the rest of this section assumes that the initial tax rate, and therefore the efficiency effect, is zero. If foreigners own the entire domestic capital stock, initial changes in the value of domestic capital stock are no longer transmitted to the value of domestic financial assets, which are, therefore, fixed in the short run.

In the absence of efficiency gains, a lower CIT impacts the level of domestic financial assets neither in the short nor the long run. However, financial assets are likely to fall below their initial level during the transition, as domestic households smooth their consumption in anticipation of rising wages. Financial assets experience a transitional rise above their initial level only if the discount rate exceeds the interest rate and, at the same time, capital accumulation occurs slowly. In that case, wages rise only slowly and

consumption-smoothing is less important. At the same time, the currently alive lose most from the decline in after-tax wages that is due to the budgetary costs of the lower CIT because, if the discount rate exceeds the interest rate, they depend most on human wealth.

The ITC produces a higher level of domestic financial assets than a lower CIT does if the interest rate exceeds the discount rate. In that case, in contrast to a lower CIT, the ITC raises financial assets in the long run. Nevertheless, saving still falls on impact because households anticipate rising wages and, therefore, reduce their saving as they smooth their consumption intertemporally. Moreover, newly born generations are hurt most by the initial budgetary costs of the investment subsidies, as they depend more on human wealth than do the older generations who own positive financial wealth. However, the fall in financial assets is only temporary, as the effect of consumption-smoothing falls off when the rate at which wages rise declines. Furthermore, the intergenerational distribution changes in favor of newly born generations when net wages eventually rise above their initial value.

7. Net foreign assets and trade performance

This section examines the effects of the investment-promoting policies on the external accounts, which are summarized in table 4. Net foreign assets are derived by subtracting the value of the domestic capital stock from financial assets owned by domestic households:

$$\tilde{F} = \tilde{A} - z(\tilde{q} + \tilde{k}). \quad (7.1)$$

Here, \tilde{F} is defined in analogy to \tilde{A} as

$$\tilde{F} = (r - n) \frac{dF}{y}. \quad (7.2)$$

The policy shocks affect the initial value of net foreign assets only if foreigners own part of the capital stock:

$$\tilde{F}(0) = -(1 - s_k) z \tilde{q}(0). \quad (7.3)$$

Accordingly, capitalization effects raising the value of domestic capital worsen the foreign asset position if foreigners own part of the domestic capital stock. In the long run, net foreign assets are given by [from (3.1), (3.9), (6.1) and (A.11) in appendix A]

$$\tilde{F}(\infty) = -\frac{\sigma_k}{1 - \alpha_k} \left[z - \left(\frac{(r - \delta)/\sigma}{r + \theta} \right) \left(\frac{r - n}{h^*} \right) t_k \alpha_k \right] (\tilde{t}_k - \tilde{t}_I)$$

Table 4
Effects on external trade account, external current account and net foreign assets.

	$\tilde{T}B(0)$	$\tilde{F}(0)$	$\dot{\tilde{F}}(0)$	$\tilde{F}(\infty)$
<i>Component:</i>				
Investment and efficiency ^a	—	0	—	— ^b
$\tilde{t}_k > 0$:				
Intergenerational distribution ($s_k = 1$) ^c	—	0	—	0
International distribution ($s_k = 0$)	+	—	+ ^d	0
$-\tilde{t}_l > 0$:				
Intergenerational distribution ($s_k = 1$) ^c	+/- ^e	0	-/+ ^e	+
International distribution ($s_k = 0$)	-/+ ^f	+/- ^e	+ ^g	+

^aThis effect is the same for both investment-promoting policies. It dominates if h and σ_k are large.

^bUnless $r > \delta$, $n + \theta$ is small, and t_k is large.

^cThis effect dominates if $(n + \theta)$ is large.

^dUnless $r > \delta$ and h or $(n + \theta)$ are small.

^e+ if h is large; — if h is small.

^f— if h is large; + if h is small.

^gUnless $r > \delta$ and both h is small and $(n + \theta)$ is small.

$$+ z \left(\frac{\Delta(n + \theta)}{h^*(r + \theta)} (-\tilde{t}_l) \right). \quad (7.4)$$

The development over time of the ratio of net foreign assets to domestic income yields the growth-adjusted external current account balance:

$$\frac{\dot{\tilde{F}}}{r - n} = \tilde{F} + \tilde{T}B. \quad (7.5)$$

Here, $\tilde{T}B$ stands for the change in the trade balance relative to initial domestic income. The trade balance can also be written as the difference between supply and demand for commodities:

$$\tilde{T}B = \tilde{y} - a_c \tilde{C} - a_l(\tilde{x} + \tilde{k}), \quad (7.6)$$

where capital accumulation determines domestic supply:

$$\tilde{y} = \alpha_k \tilde{k}. \quad (7.7)$$

The short-run change in the trade balance, $\tilde{T}B(0)$, is found by substituting into (7.6) the initial effects on consumption demand [from (4.1) and (5.2)] and on investment demand (from appendix A):

$$\begin{aligned}
\tilde{T}B(0) = & - \left[\left(\frac{h}{r-n} \right) z + \left(\frac{\Delta}{r+\theta} \right) \left(\frac{h}{h+r+\theta} \right) t_k \alpha_k \right] \frac{\sigma_k}{1-\alpha_k} (\tilde{t}_k - \tilde{t}_I) \\
& + s_k \Delta (n+\theta) \left\{ - \frac{(1-t_k)\alpha_k}{(r+\theta+h)(r-n+h)} (\tilde{t}_k - \tilde{t}_I) \right. \\
& \quad \left. + \frac{z}{(r+\theta)(r-n)} (-\tilde{t}_I) \right\} \\
& + (1-s_k) \Delta \left[\frac{(1-t_k)\alpha_k(\tilde{t}_k - \tilde{t}_I)}{(r+\theta+h)} - \frac{z(-\tilde{t}_I)}{(r+\theta)} \right]. \tag{7.8}
\end{aligned}$$

Substituting the initial changes in net financial assets (6.3), the capital stock [from (3.2) and (3.1)] and the value of the capital stock [from (A.11) and (A.10) in appendix A] into the time derivative of (7.1), one derives for the initial current account response:

$$\begin{aligned}
\frac{\dot{\tilde{F}}(0)}{r-n} = & - \left[\left(\frac{h}{r-n} \right) z + \left(\frac{\Delta}{r+\theta} \right) \left(\frac{h}{h+r+\theta} \right) t_k \alpha_k \right] \frac{\sigma_k}{1-\alpha_k} (\tilde{t}_k - \tilde{t}_I) \\
& + s_k \Delta (n+\theta) \left\{ - \frac{(1-t_k)\alpha_k}{(r+\theta+h)(r-n+h)} (\tilde{t}_k - \tilde{t}_I) \right. \\
& \quad \left. + \frac{z}{(r+\theta)(r-n)} (-\tilde{t}_I) \right\} \\
& + (1-s_k) \left\{ \left[\frac{h(n+\theta)}{(r+\theta+h)(r-n+h)} - \frac{(r-\delta)/\sigma}{h+r+\theta} \right] (1-t_k)\alpha_k(\tilde{t}_k - \tilde{t}_I) \right. \\
& \quad \left. + \frac{(r-\delta)/\sigma}{(r+\theta)} z(-\tilde{t}_I) \right\}. \tag{7.9}
\end{aligned}$$

7.1. Without foreign ownership

If domestic households initially own the entire domestic capital stock, the policy shocks alter neither the initial net foreign asset position nor short-run net foreign investment income. As a direct consequence, the change in the

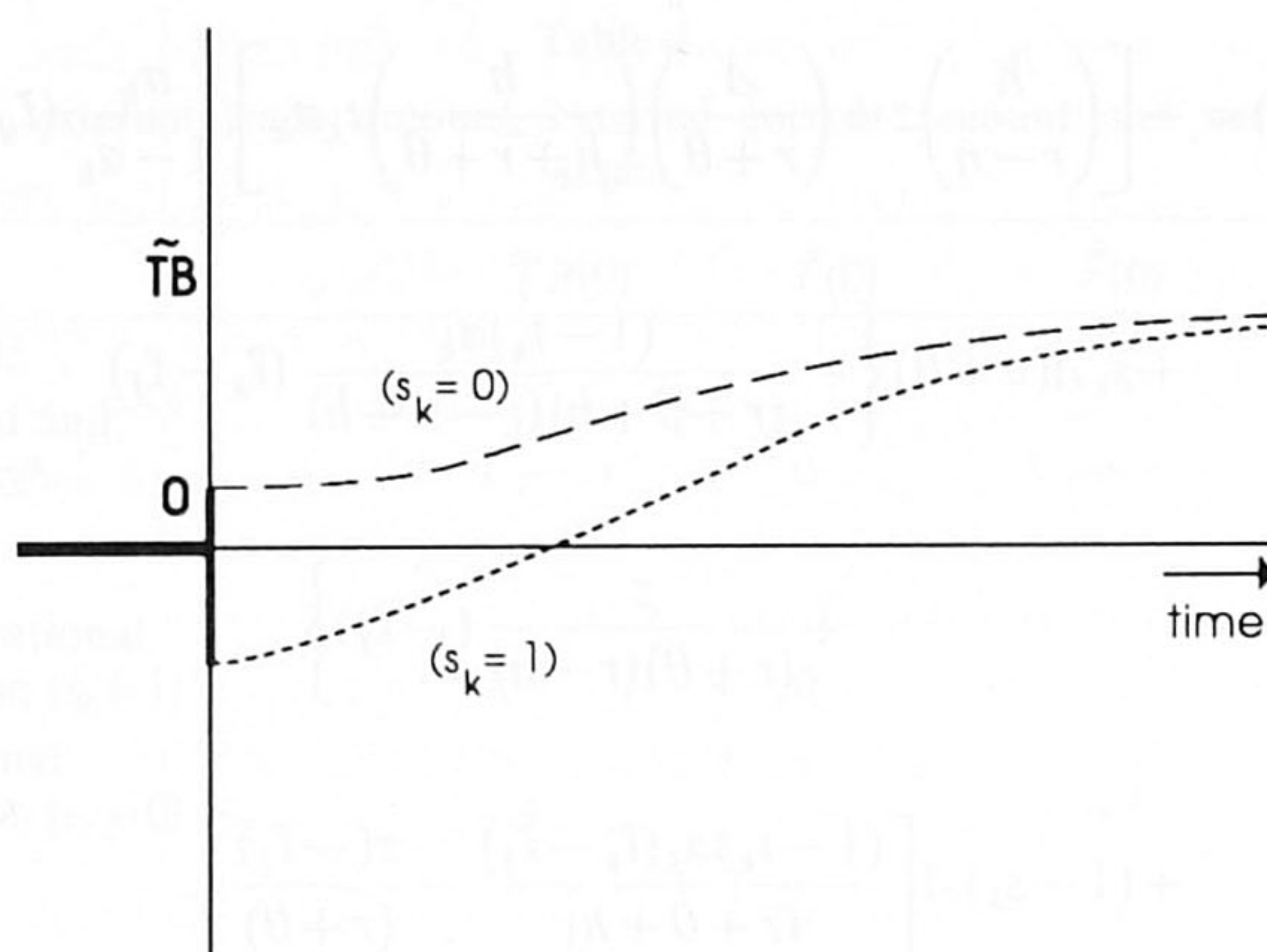


Fig. 9. Trade balance effect of lower CIT.

trade balance discounted by the effective discount rate, $r-n$, is zero. Furthermore, the initial response of the trade balance corresponds to the short-run impact on the current account.

A lower CIT worsens the initial trade performance on account of not only a rise in investment demand, but also two negative saving effects. Whereas domestic supply is fixed in the short run, both investment and consumption demand rise. The first term in the first square brackets in (7.8) and (7.9) represents the effect of higher investment demand on domestic absorption. The second term in the first square brackets and the terms on the second line in (7.8) and (7.9) stand for the negative saving effects associated with a lower CIT. The term on the first line involves consumption-smoothing in anticipation of a gain in intertemporal efficiency, while the terms on the second line concern the intergenerational distributional effect in favor of the currently alive (see section 6).

How a smaller adjustment speed and a higher birth rate affect the magnitude of the initial deterioration of the trade balance is ambiguous. On the one hand, they weaken the negative saving effect of enhanced intertemporal efficiency but, on the other hand, they strengthen the negative saving effect associated with the intergenerational distributional effect. A smaller adjustment speed also dampens the short-run investment response.

After its initial deterioration, the trade balance begins to recover for two reasons (see fig. 9). First, domestic supply meets a larger part of domestic demand as capital accumulation raises domestic production capacity. Second, domestic demand declines over time due to a fall in both consumption demand (see section 5) and investment demand. Eventually, the trade balance improves relative to the initial steady state. The improved trade performance

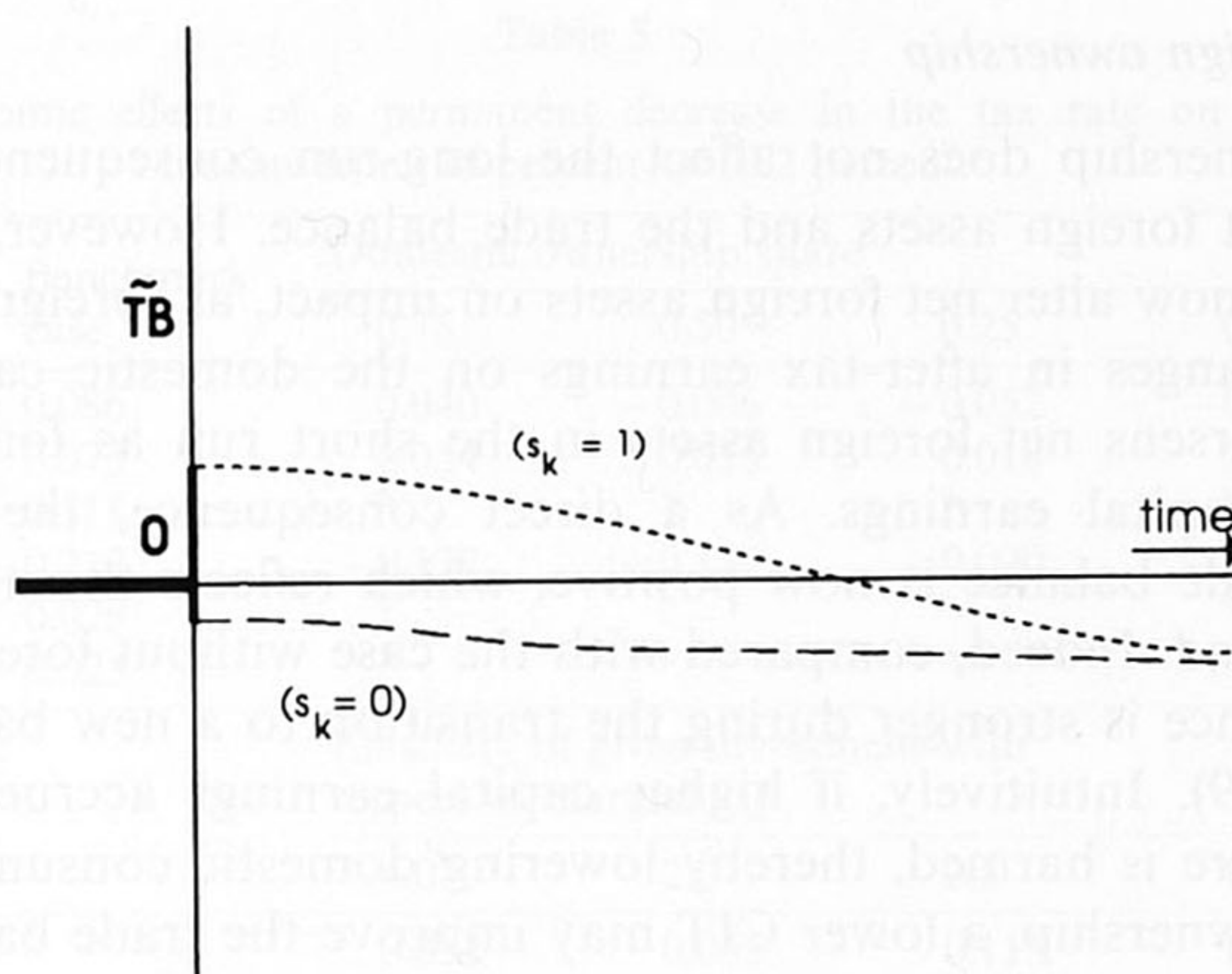


Fig. 10. Trade balance effect of ITC (h and $n + \theta$ large, t_k small).

provides the resources to finance the larger flow of investment income paid to foreigners abroad, which corresponds to the weaker net foreign assets position.

Compared with a lower CIT, the ITC yields a stronger initial trade balance. The reason is that the ITC works less in favor of the currently alive than a lower CIT does. Accordingly, initial consumption is lower and initial saving is higher (see sections 5 and 6). In fact, the ITC may improve the initial trade and current account balances if the saving impact of the intergenerational distributional effect in favor of future generations is sufficiently strong to offset the positive investment effect and the negative saving effect on account of improved intertemporal efficiency (see fig. 10). This will be the case if a small substitution elasticity between labor and capital yields small investment and efficiency effects. Furthermore, rapid capital accumulation and a high birth rate should cause future generations to gain substantially at the expense of the currently alive.

The long-run consequences of the ITC for net foreign assets are ambiguous. The substitution elasticity between capital and labor is an important determinant of the sign of this effect. If this elasticity is large, net foreign assets are likely to fall in the new steady state, which corresponds to a stronger long-run trade performance. Intuitively, domestic saving is not sufficient to finance the large expansion of the domestic capital stock that is produced by the easy substitution between labor and capital. If the substitution elasticity is small, in contrast, the ITC is likely to boost net foreign assets, as domestic residents accumulate foreign assets to compensate for the unanticipated capital losses on their holdings of domestic capital produced by the lower after-tax price of new investment goods.

7.2. *With foreign ownership*

Foreign ownership does not affect the long-run consequences of the two policies for net foreign assets and the trade balance. However, unanticipated policy shocks now alter net foreign assets on impact, as foreigners absorb the capitalized changes in after-tax earnings on the domestic capital stock. A lower CIT worsens net foreign assets in the short run as foreigners benefit from higher capital earnings. As a direct consequence, the effect on the discounted trade balance is now positive, which reflects the need to transfer resources abroad. Indeed, compared with the case without foreign ownership, the trade balance is stronger during the transition to a new balanced growth path (see fig. 9). Intuitively, if higher capital earnings accrue to foreigners, domestic welfare is harmed, thereby lowering domestic consumption. In fact, with foreign ownership, a lower CIT may improve the trade balance not only in the long run but also in the short run. This is the case if a low substitution elasticity in production and slow capital accumulation induce a weak response of short-run investment demand. At the same time, a high birth rate should induce a strong negative consumption response by ensuring that rising wages produced by capital accumulation accrue to future rather than current generations. The discount rate exceeding the interest rate also contributes to an initial trade surplus by reducing short-run consumption. Intuitively, under these circumstances current generations depend more on human capital than future generations do. They lose most, therefore, from the fall in after-tax wages.

The ITC is less beneficial to foreigners than a lower CIT is. In fact, the ITC amounts to an implicit tax on foreign owners of domestic capital if rapid adjustment causes the value of the domestic capital stock to fall on impact. In that case, net foreign assets improve initially. Compared with the case without foreign ownership, therefore, the domestic economy can afford to run a larger discounted trade deficit accompanied by a higher level of domestic consumption (see fig. 10).

The ITC yields a stronger short-run trade balance than a lower CIT does if domestic capital is initially owned domestically. However, if foreigners own the entire domestic capital stock, the ITC produces the weakest initial trade performance of the two alternative policies if the discount rate exceeds the interest rate. The reason is that the ITC yields uniformly higher after-tax earnings than a lower CIT does and, therefore, benefits current generations, who depend most on human capital.

8. **Parameterized examples**

This section illustrates the analytical results of the paper by presenting quantitative estimates for the macroeconomic effects of the investment-

Table 5
Macroeconomic effects of a permanent decrease in the tax rate on capital income from 20 percent to 19.2 percent.^a

	Benchmark case	Domestic ownership share			
		0.75	0.50	0.25	0.0
$\tilde{C}(0)$	0.086	0.040	-0.006	-0.052	-0.099
$\tilde{A}(0)$	0.073	0.054	0.036	0.018	0.0
$\tilde{H}(0)$	-0.118	^b	^b	^b	^b
$\tilde{T}B(0)$	-0.212	-0.172	-0.131	-0.090	-0.049
h	0.029	^b	^b	^b	^b
h^*	0.025	^b	^b	^b	^b
		Elasticity of gross investment with respect to marginal Q			
		4.0	2.0	0.5	0.2
$\tilde{C}(0)$		0.052	0.065	0.115	0.161
$\tilde{A}(0)$		0.042	0.056	0.093	0.120
$\tilde{H}(0)$		-0.064	-0.091	-0.144	-0.173
$\tilde{T}B(0)$		-0.356	-0.266	-0.188	-0.187
h		0.066	0.044	0.019	0.010
h^*		^b	^b	^b	^b
		Probability of death			
		-0.01	0.00	0.02	0.05
$\tilde{C}(0)$		0.024	0.055	0.119	0.229
$\tilde{A}(0)$		^b	^b	^b	^b
$\tilde{H}(0)$		-0.085	-0.104	-0.129	-0.151
$\tilde{T}B(0)$		-0.169	-0.189	-0.239	-0.326
h		^b	^b	^b	^b
h^*		0.005	0.015	0.035	0.065

^aBenchmark parameter values are: net investment share $a_I=0.078$; net capital income share $\alpha_k=0.222$; rate of capital income tax $t_k=0.2$; substitution elasticity between labor and capital in net production $\sigma_k=0.741$; elasticity of net investment with respect to marginal $Q(1/\sigma_x)=9.9$; intertemporal substitution elasticity in consumption $(1/\sigma)=0.5$; real world rate of return $r=0.04$; population growth $n=0.02$; rate of time preference $\delta=0.0375$.

^bSame effect as in benchmark simulation.

promoting policies. In particular, tables 5 and 6 present the short-term effects of, respectively, a lower source-based tax rate and an investment subsidy on economy-wide consumption, financial capital, human capital and the trade balance. It also contains the two adjustment speeds, h and h^* , in order to indicate how rapidly the economy converges to its new steady state.

The specific parameter values required to carry out the simulation analysis are presented at the end of table 5. The initial rate of the source-based capital income tax is 20 percent. In the benchmark simulation, the domestic capital stock is entirely owned by domestic residents on the initial balanced growth path, while the value for the adjustment cost elasticity, σ_x , is based on an elasticity of gross investment with respect to a marginal Q of 1, which

Table 6
Macroeconomic effects of the introduction of a permanent investment subsidy of 1 percent.^a

	Benchmark case	Domestic ownership share			
		0.75	0.50	0.25	0.0
$\tilde{C}(0)$	-0.066	-0.049	-0.032	-0.014	0.003
$\tilde{A}(0)$	-0.027	-0.021	-0.014	-0.007	0.0
$\tilde{H}(0)$	0.003	^b	^b	^b	^b
$\tilde{T}B(0)$	-0.078	-0.093	-0.109	-0.123	-0.139
		Elasticity of gross investment with respect to marginal Q			
		4.0	2.0	0.5	0.2
$\tilde{C}(0)$		-0.100	-0.087	-0.040	0.009
$\tilde{A}(0)$		-0.059	-0.045	-0.007	0.020
$\tilde{H}(0)$		0.058	0.031	-0.023	-0.052
$\tilde{T}B(0)$		-0.221	-0.131	-0.054	-0.051
		Probability of death			
		-0.01	0.00	0.02	0.05
$\tilde{C}(0)$		-0.007	-0.037	-0.094	-0.166
$\tilde{A}(0)$		^b	^b	^b	^b
$\tilde{H}(0)$		0.037	0.018	-0.008	-0.030
$\tilde{T}B(0)$		-0.128	-0.101	-0.056	0.001

^aFor benchmark parameter values, see table 5.

^bSame effect as in benchmark simulation.

compares with an estimate for this latter elasticity of 1/2 in Summers (1981). The intertemporal substitution elasticity in consumption, $(1/\sigma)$, is 1/2. The substitution elasticity between labor and capital in net production is based on a unitary elasticity in gross production. The net income shares of net investment and net capital income are derived from gross shares of, respectively, 17 percent and 30 percent and a share of depreciation in gross income of 10 percent. The fixed real rate of return on world capital markets and the rate of population growth amount to, respectively, 4 and 2 percent. In the benchmark case, the probability of death is 1 percent. Table 5 examines also the sensitivity of the results with respect to alternative assumptions regarding the elasticity of gross investment with respect to marginal Q , the probability of death, and the share of the domestic capital stock that is owned by domestic residents in the initial steady state.

The investment-promoting policies correspond to an investment subsidy of 1 percent. This implies that the source-based capital income tax rate is reduced by 0.8 percentage points, from 20 to 19.2 percent, so as to provide the same impulse to investment as the investment subsidy does.

Lowering the tax rate to 19.2 percent boosts initial consumption by almost 0.09 percent in the benchmark case. Higher investment and consumption

demand cause the short-run trade balance to worsen by a little over 0.2 percent of net domestic income. The sensitivity analysis reveals that the tax cut produces the largest short-run deterioration of the trade balance if investment is elastic and the probability of death is large. In particular, the trade balance worsens by 0.36 percent of net domestic income if an elasticity of gross investment with respect to Q of 4 yields high short-run investment. The initial deterioration of the trade balance amounts to 0.33 percent of net domestic income if a high probability of death produces a strong initial response of consumption demand.

A lower tax rate reduces short-run consumption only if foreigners own more than half of the domestic capital stock in the initial equilibrium. Even if foreigners own the entire domestic capital stock initially and short-run consumption declines, the trade balance still does not improve in the short run.²⁰

The benchmark simulation reveals that an investment subsidy, in contrast to a lower tax rate, reduces consumption initially as current generations suffer from a fall in their financial wealth. In particular, an investment subsidy of 1 percent cuts short-run consumption by 0.07 percent. The sensitivity analysis shows that an investment subsidy boosts initial consumption only if either the investment elasticity is extremely low or if foreigners initially own the entire domestic capital stock. Despite the rather weak response of consumption demand in the short run, the initial trade balance typically worsens, as higher investment demand more than offsets the effect of lower consumption on aggregate domestic demand. In the benchmark case, the initial deterioration of the trade balance amounts to about 0.08 percent of net domestic income. Only if horizons are short (corresponding to a probability of death of 5 percent) does the drop in consumption demand offset higher investment demand so that the short-run trade balance is virtually unaffected.

9. Pareto-improving policies

This section examines three alternative ways to ensure that – starting from an initial distorted equilibrium – investment-promoting policies are Pareto improving by neutralizing the intergenerational and international distributional effects. A policy is defined to be distributionally neutral if it does not affect foreigners and if all generations at home experience the same *absolute* change in (ex ante or expected) welfare per capita. Hence, all generations at home share in the overall efficiency gain (if $t_k > 0$) and the investment-promoting policy is Pareto improving. According to the above definition,

²⁰A simulation not shown in the tables indicates that the trade balance improves initially if a low investment elasticity of 1/2 is combined with foreign ownership.

policy is intergenerationally neutral if two conditions are met. First, discounted capital earnings should be unchanged:

$$\tilde{q}^*(0) = 0. \quad (9.1)$$

Second, following the implementation of the policy, labor earnings should be constant over time and reflect the overall efficiency effect (see appendix C):

$$a_\omega \tilde{\omega}^*(t) = \left(\frac{h}{h+r-n} \right) t_k \alpha_k \left(\frac{\sigma_k}{1-\alpha_k} \right) (\tilde{t}_k - \tilde{t}_l), \quad (9.2)$$

where an asterisk indicates the case of a distributionally-neutral policy.

9.1. Debt policy and a wealth tax

One way to ensure that the value of the domestic capital stock is unaffected is to offset the windfall gains or losses produced by the investment-promoting policies by a one-time wealth tax on the domestic capital stock at the time the unanticipated policy shock is announced. The government uses the expropriated wealth to finance transfers that supplement labor income. From the government budget constraint, the discounted value of these transfers (at time $t=0$) equals the revenues collected from the wealth tax:

$$(r-n) L_{\tilde{l}}(r-n) = \left(\frac{r-n}{r-n+h} \right) (1-t_k) \alpha_k (\tilde{t}_k - \tilde{t}_l) - z(-\tilde{t}_l), \quad (9.3)$$

where $L_{\tilde{l}}(s)$ denotes the Laplace transform of the change in debt-financed lump-sum transfers relative to domestic income, $\tilde{l}(t)$.²¹ The time path for transfers that generates constant labor earnings (9.2) and meets the government budget constraint is (see appendix C)

$$\begin{aligned} \tilde{l}(t) = & t_k \alpha_k \frac{\sigma_k}{1-\alpha_k} (\tilde{t}_k - \tilde{t}_l) \left[e^{-ht} - \left(\frac{r-n}{h+r-n} \right) \right] \\ & + (1-t_k) \alpha_k (\tilde{t}_k - \tilde{t}_l) e^{-ht} - z(-\tilde{t}_l). \end{aligned} \quad (9.4)$$

The first term on the right-hand side of (9.4) involves the efficiency effect. The government initially provides positive debt-financed transfers in order to have older generations share in the intertemporal efficiency gains, which raise

²¹The Laplace transform of $G(t)$ is $L_G(s)$, where $L_G(s) = \int_0^\infty e^{-st} G(t) dt$. Intuitively, the Laplace transform of $G(t)$ is the present value of the flow $G(t)$ discounted at s .

wages only as capital accumulates over time. In the long run, the government levies a tax on younger generations to finance the earlier transfers. Hence, debt policy transfers resources from younger generations, who benefit from higher labor earnings, to older generations.

The other terms concern the intergenerational distributional effects. A lower CIT requires positive transfers during the entire transition to a new steady state in order to offset lower after-tax wages. In other words, the government uses debt issue rather than taxes on labor to finance part of the lower CIT. In fact, immediately after the CIT is reduced the government relies entirely on debt finance. Labor taxes implemented at $t=0$ would reduce after-tax wages because capital accumulation has not yet raised before-tax labor earnings. Only after capital accumulation has boosted the marginal productivity of labor can the government finance part of the lower CIT through higher taxes on labor without reducing after-tax wages. However, in the absence of any first-order efficiency effect ($t_k=0$), debt finance continues to play a role during the entire transition to a new steady state. The ITC, in contrast, requires positive transfers corresponding to debt finance only initially. Eventually, transfers become negative when capital accumulation raises after-tax wages above their initial steady-state level. Accordingly, in the case of the ITC, public debt is positive in the new steady state. In the case of a lower CIT, public debt approaches zero in the long run if there are no efficiency effects ($t_k=0$). However, long-run public debt will be positive if a positive initial tax rate gives rise to a first-order efficiency effect.

9.2. Debt policy and simultaneous permanent changes in two instruments

Rather than explicitly expropriating part of the domestic capital stock, the fiscal authorities can also implement a combination of the two permanent investment-promoting policies in such a way that the value of the domestic capital stock does not change. Using (3.4), one finds that the share of the investment subsidy, $-\tilde{t}_I$, in the total investment impulse, $(\tilde{t}_k - \tilde{t}_I)$, equals

$$\frac{-\tilde{t}_I}{(\tilde{t}_k - \tilde{t}_I)} = \left(\frac{r-n}{r-n+h} \right) \frac{(1-t_k)\alpha_k}{z}. \quad (9.5)$$

A slower speed of capital accumulation requires a larger role for the investment subsidy. If slow adjustment causes the ITC to raise the value of capital, the ITC share may even exceed unity so that, instead of falling, the CIT rises on impact. Intuitively, with slow adjustment, capital owners tend to benefit from investment-promoting policies. Accordingly, the government needs to increase the CIT to offset the undesired capitalization effects, while using the ITC to provide the stimulus to investment. Solving for the public transfers that are required to meet (9.2), one finds (see appendix C)

$$\tilde{l}(t) = \left[t_k \alpha_k \frac{\sigma_k}{1 - \alpha_k} + (1 - t_k) \alpha_k \right] (\tilde{t}_k - \tilde{t}_l) \left[e^{-ht} - \left(\frac{r - n}{h + r - n} \right) \right]. \quad (9.6)$$

In contrast to the first distributionally-neutral policy, discounted transfers are zero because the government starts with zero public debt. After the investment-promoting policies are implemented, the government starts to accumulate public debt when it provides debt-financed transfers to labor to offset an initial fall in after-tax wages.²² Eventually, however, debt-financed transfers become negative when capital accumulation causes after-tax wages to exceed their initial steady-state level. On the new balanced growth path, taxes on labor finance the interest costs associated with a positive level of public debt. In effect, part of the budgetary costs of the investment-promoting policy is shifted to younger generations, who benefit from these policies through higher before-tax wages. Indeed, the taxes required to service the public debt can be interpreted as a ‘benefit tax’.

9.3. Time-varying fiscal policies without debt policy

The government does not have to adopt debt policy to ensure that the investment-promoting policies are Pareto improving. In particular, it can vary over time the weight of the investment subsidy in the total permanent investment impulse in such a way that the return to human capital meets (9.2). Using (3.7), (3.8) and (3.9) and solving for (9.2) one finds

$$\begin{aligned} z \frac{-\tilde{t}_l(t)}{(\tilde{t}_k - \tilde{t}_l)} &= \left[(1 - t_k) \alpha_k + t_k \alpha_k \frac{\sigma_k}{1 - \alpha_k} \right] e^{-ht} \\ &\quad - \left(\frac{r - n}{r - n + h} \right) t_k \alpha_k \frac{\sigma_k}{1 - \alpha_k}. \end{aligned} \quad (9.7)$$

The weight of the ITC exceeds unity in the short run. However, if the initial CIT is positive, the ITC falls below zero in the long run. Intuitively, investment-promoting policies decrease after-tax wages in the short run but increase them above their sustainable level, given by (9.2), in the long run. Therefore, the combination of the two policies serves to transfer resources to labor in the short run but to tax labor in the long run. At the same time, the policy mix should provide a constant combined investment impulse $(\tilde{t}_k - \tilde{t}_l)$.

Initially, the capital stock and, therefore, before-tax wages are fixed. Accordingly, the government cannot use labor taxes to finance the

²²An alternative interpretation is that the government uses debt issue rather than labor taxes to finance the investment-promoting policies.

investment-promoting policies because doing so would violate (9.2). Instead, the CIT is raised to provide the budgetary funds to finance the investment subsidy. Intuitively, old capital is taxed to subsidize marginal investment. As time elapses, capital accumulation raises before-tax wages and the government gradually reduces the CIT, as it now can levy taxes on labor to finance investment incentives while keeping after-tax wages from rising above (9.2). At the same time, the ITC is reduced. Eventually, the CIT is decreased compared with its initial steady-state level. On the new balanced growth path, the ITC is completely eliminated if the initial tax rate is zero. If a positive tax rate yields a positive efficiency effect, the government taxes labor in order to scale back labor earnings to their discounted efficiency gain and uses the revenues to further reduce the CIT. At the same time, the government levies a positive investment tax in order to offset the excessive investment incentives originating from the reduction in the CIT.

9.4. The macroeconomic effects of Pareto-improving policies

Distributionally-neutral policies yield the following path for consumption:

$$a_{\omega} \tilde{C}(t) = \frac{h}{h+r-n} t_k \alpha_k \left(\frac{\sigma_k}{1-\alpha_k} \right) (\tilde{t}_k - \tilde{t}_l) \left[1 - \frac{(r-\delta)/\sigma}{n+\theta} e^{-h^* t} \right]. \quad (9.8)$$

Consumption is fixed at its initial value if the initial tax rate on capital is zero. In the presence of a first-order gain in intertemporal efficiency, however, the policies are Pareto improving and consumption rises on impact. Consumption stays constant at its higher level only if the interest rate equals the discount rate. In that case, financial wealth is zero and the rise in human wealth implies the same *relative* change in welfare for all generations. However, if older generations hold positive financial wealth (i.e. $r > \delta$), they gain *relatively* less from higher human wealth because they depend less on human wealth for their consumption. Hence, consumption rises as younger generations who benefit *relatively* more are born.

The trade balance deteriorates initially due to an increase in investment demand, and if the initial tax rate on capital is positive, an increase in consumption demand. In the long run, the trade performance improves due to the capacity effects of investment.

10. Conclusions

Using an intertemporal equilibrium model, this paper shows how intergenerational and international distribution effects, in addition to intertemporal efficiency effects, affect the macroeconomic consequences of investment-

promoting policies. Whereas intergenerational distributional effects may weaken the initial expansionary effects of the ITC, they strengthen the short-run positive effects on domestic absorption exerted by a lower CIT if foreigners do not own any domestic capital when the policies are implemented. In particular, without foreign ownership of domestic capital, intergenerational redistribution caused by a lower CIT boosts initial consumption at the expense of future consumption, especially if both the birth rate and the adjustment costs in investment are high. Accordingly, these effects on the timing of consumption strengthen the initial deterioration and eventual improvement of the trade balance associated with the initial demand effects and eventual supply effects of capital accumulation. The ITC, in contrast, may reduce consumption initially if rapid capital accumulation causes a redistribution from current to future generations. The associated positive saving effect may be sufficiently strong to entirely finance the investment impulse if the birth rate is high. Accordingly, the ITC may cause the trade balance to improve on impact.

In contrast to the domestic intergenerational redistribution effects, the international redistributional effects of a lower CIT dampen the expansionary effects of the stimulus to investment. In particular, if foreigners own part of the domestic capital stock, a lower CIT results in a redistribution of wealth away from domestic households – including those who are alive at the time of policy shock – to foreigners. Hence, domestic current consumption falls and, therefore, makes room to transfer resources abroad through an improved trade performance. The international redistribution of the ITC, in contrast, boosts domestic consumption if rapid capital accumulation results in a windfall loss for foreigners.

The paper explores a number of ways to neutralize the intergenerational distributional effects of the investment-promoting policies in order to arrive at Pareto-improving policies. For example, instead of using current taxes to balance its budget at each point in time, the government can use debt policy to shift the burden of financing the investment incentives to younger generations, who benefit from capital accumulation. In particular, the government can issue debt to finance the initial budgetary costs associated with investment-promoting policies in order to relieve the burden on older generations. Younger generations, who benefit from higher wages produced by capital accumulation, pay part of the budgetary costs of the investment-promoting policies by servicing the additional public debt. The paper also shows that the government can employ tax policy to arrive at the same intergenerational distribution as achieved by explicit debt policy. In particular, it can boost capital accumulation by initially relying (mainly) on the ITC financed by a higher CIT. As the capital stock expands, the government increasingly resorts to a lower CIT financed by taxes on labor.

The study provides a number of lessons for modelling the impact of fiscal

policies on international trade and capital flows. First, the modelling of the interaction between, on the one hand, disconnected generations determining aggregate saving, and, on the other hand, adjustment costs affecting investment behavior, gives rise to intergenerational distributional effects, which potentially exert powerful macroeconomic effects. Second, foreign ownership can generate international distribution effects, which may impact domestic consumption and trade performance. Third, two-period models cannot fully characterize the dynamics generated by the intergenerational distributional effects of investment incentives. In particular, the study reveals that investment-promoting policies can yield important non-monotonicities in consumption and asset accumulation.

Notation

Aggregate variables measured per capita

C	Consumption demand
k	Capital stock
y	Domestic supply of commodities (net of depreciation)
A	Financial wealth
H	Human wealth
W	Total domestic wealth
F	Net foreign assets

Other variables

x	Ratio of the net investment demand to capital stock
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Price variables

w	Before-tax wage
ω	After-tax labor earnings
q	Shadow price of domestic capital stock
r	Rate of return on world financial markets

Tax rates

t_k	Tax rate on capital income (net of depreciation)
t_I	Subsidy rate on net investment

Parameters

n	Rate of population growth
δ	Rate of time preference
h	Speed of capital accumulation
$(1/\sigma)$	Intertemporal substitution elasticity in consumption
σ_x	Elasticity of the marginal productivity of net investment in installation
σ_k	Substitution elasticity between capital and labor in net production

Shares in domestic output

α_k Capital income (net of depreciation)

a_I Net investment

$z = (1 - t_k)\alpha_k - a_I$ Cash flow

a_c Private consumption

$a_w = (1 - \alpha_k) + t_k\alpha_k$ After-tax labor earnings

A dot above a variable denotes a time derivative and, unless indicated otherwise, a tilde represents a change relative to the initial steady-state equilibrium. A tilde above a tax or subsidy rate $t_n, n = k, I$, is defined as $d(1 - t_n)/(1 - t_n)$.

A tilde above A is defined as $(r - n)dA/y$. F is defined analogously. The time derivative of a relative change is denoted by the combination of a tilde and a dot. Under certain regularity conditions, this equals the policy-induced change in the rate of growth.

Appendix A: The investment system

A.1. Steady-state relationships

The elasticities in the log-linearized model are assumed to be fixed at their values in the initial steady-state equilibrium. In order to express these elasticities in terms of observable shares, the paper uses two steady-state relationships [(A.1) and (A.4) below] that follow from (2.11) and (2.14), respectively.

On a balanced growth path, the capital–labor ratio is constant. Accordingly, (2.11) yields the following steady-state relationship:

$$g(x) = n. \quad (\text{A.1})$$

Setting the left-hand side of (2.14) equal to zero and using (A.1), one derives

$$(r - n)q = (1 - t_k)f'(k) - (1 - t_I)x. \quad (\text{A.2})$$

On the initial balanced growth path, the investment subsidy is assumed to be zero (see subsection 2.4):

$$t_I = 0. \quad (\text{A.3})$$

Substituting (A.3) into (A.2), one finds the following steady-state relationship between the capital–output ratio and the share of the cashflow in output, z :

$$(r - n) \frac{qk}{f(k)} = z = (1 - t_k)\alpha_k - a_I. \quad (\text{A.4})$$

A.2. The log-linearized model

The dynamic equations are found by log-linearizing (2.11) and (2.14), respectively:

$$\dot{\tilde{k}} = g'(x)x\tilde{x}, \quad (\text{A.5})$$

$$\begin{aligned} \dot{\tilde{q}} = & -\left(\frac{(1-t_k)f''(k)k}{q}\right)\tilde{k} + \left(\frac{(1-t_k)f'(k) - (1-t_I)x}{q}\right)\tilde{q} \\ & -\left(\frac{(1-t_k)f'(k)}{q}\right)\tilde{t}_k + (1-t_I)\frac{x}{q}(\tilde{x} + \tilde{t}_I) - g'(x)x\tilde{x}. \end{aligned} \quad (\text{A.6})$$

In order to eliminate \tilde{x} from (A.5) and (A.6), one uses the following log-linearized version of (2.15):

$$\tilde{q} - \sigma_x \tilde{x} = \tilde{t}_I. \quad (\text{A.7})$$

Then, the steady-state elasticities in (A.5) and (A.6) are rewritten by eliminating $g'(x)$ from (2.15), eliminating q from (A.4), imposing (A.3), and using the definition of σ_k :

$$\sigma_k = -\left(\frac{f'(k)}{f''(k)k}\right)(1-\alpha_k). \quad (\text{A.8})$$

This procedure gives rise to the two-dimensional investment system:

$$\begin{aligned} \begin{bmatrix} \dot{\tilde{k}} \\ \dot{\tilde{q}} \end{bmatrix} = & (r-n) \begin{bmatrix} 0 & \frac{a_I}{\sigma_x z} \\ \left(\frac{(1-t_k)\alpha_k}{z}\right)\left(\frac{1-\alpha_k}{\sigma_k}\right) & 1 \end{bmatrix} \begin{bmatrix} \tilde{k} \\ \tilde{q} \end{bmatrix} \\ & + (r-n) \begin{bmatrix} 0 & \frac{a_I}{z\sigma_x} \\ -\frac{(1-t_k)\alpha_k}{z} & -\frac{a_I}{z} \end{bmatrix} \begin{bmatrix} \tilde{t}_k \\ -\tilde{t}_I \end{bmatrix}. \end{aligned} \quad (\text{A.9})$$

A.3. The solutions

The long-run solution for the *capital-labor ratio* (3.1) is derived by setting the left-hand side of (A.9) equal to zero and solving for $\tilde{k}(\infty)$. Expression (3.3) for the *adjustment speed* to the new long-run equilibrium, h , is computed

as the absolute value of the stable (i.e. negative) root of the first elasticity matrix on the right-hand side of (A.9). Accordingly, h is the negative root of the following characteristic equation:

$$h(h+r-n) - \frac{(1-t_k)\alpha_k}{z} \frac{a_I}{z\sigma_x} \frac{(1-\alpha_k)}{\sigma_k} (r-n)^2 = 0. \quad (\text{A.10})$$

The initial jump of the value of the domestic capital stock, $\tilde{q}(0)$, is found by substituting the solution for the capital-labor ratio [from (3.1) and (3.2)] into the first row of (A.9):

$$\left(\frac{h}{r-n}\right) \left(\frac{\sigma_k}{1-\alpha_k}\right) (\tilde{t}_k - \tilde{t}_I) e^{-ht} = \frac{a_I}{\sigma_x z} (\tilde{q}(t) - \tilde{t}_I). \quad (\text{A.11})$$

Using (A.10) to eliminate the elasticities σ_x and σ_k , one arrives at (3.4).

After-tax labor earnings are derived by substituting (2.10) into (2.16) to eliminate w and log-linearizing the resulting equation:

$$a_\omega \tilde{\omega} = \left(t_k \alpha_k + (1-t_k) \alpha_k \left\{ \frac{1-\alpha_k}{\sigma_k} \right\} \right) \tilde{k} + a_I \tilde{t}_I - (1-t_k) \alpha_k \tilde{t}_k, \quad (\text{A.12})$$

where (A.3) and (A.8) have been used to rewrite the elasticities. Expressions (3.7), (3.8) and (3.9) are derived from (A.12) by substituting the time path for the capital-labor ratio [from (3.1) and (3.2)].

The relative change in human wealth (3.10) follows from log-linearizing the definition of human wealth,

$$H(t) = \int_t^\infty \omega(s) e^{-(r+\theta)(s-t)} ds, \quad (\text{A.13})$$

according to

$$\tilde{H}(0) = (r+\theta) \int_0^\infty \tilde{\omega}(t) e^{-(r+\theta)t} dt. \quad (\text{A.14})$$

Substituting (3.7), (3.8) and (3.9) into (A.14), one finds (3.10).

Appendix B: The saving system

B.1. Dynamic equations

The saving system consists of two dynamic equations in aggregate consumption, C , and financial wealth, A . The dynamic equation for consumption is found by differentiating (2.6) with respect to time:

$$\dot{C}(t) = \Delta[\dot{A}(t) + \dot{H}(t)]. \quad (\text{B.1})$$

The time derivatives on the right-hand side of (B.1) are rewritten by using the time derivative of (A.13),

$$\dot{H}(t) = (r + \theta)H(t) - \omega(t), \quad (\text{B.2})$$

and (2.7). This yields:

$$\dot{C}(t) = \left(\frac{r - \delta}{\sigma} \right) C(t) - \Delta(n + \theta)A(t). \quad (\text{B.3})$$

B.2. Steady-state relationships

In order to manipulate the elasticities, this appendix derives a number of steady-state relationships. Imposing the steady-state condition on (B.3), one finds the following expression linking A and C on a balanced-growth path:

$$A = \frac{(r - \delta)/\sigma}{\Delta(n + \theta)} C. \quad (\text{B.4})$$

The steady-state value of human wealth is given by [using (A.13)]

$$H = \frac{\omega}{r + \theta}. \quad (\text{B.5})$$

The steady-state relationship between consumption and after-tax labor earnings is found by substituting (B.4) and (B.5) into (2.6):

$$\frac{\omega}{C} = \frac{a_\omega}{a_c} = \frac{h^*(r + \theta)}{\Delta(n + \theta)}, \quad (\text{B.6})$$

where h^* is defined in (5.4).

B.3. The log-linearized model

Log-linearizing (B.3) and (2.7) produces the saving system:

$$\begin{bmatrix} \dot{\tilde{C}}(t) \\ \dot{\tilde{A}}(t) \end{bmatrix} = \begin{bmatrix} \frac{r - \delta}{\sigma} & -\frac{(n + \theta)\Delta}{a_c(r - n)} \\ -(r - n)a_c & r - n \end{bmatrix} \begin{bmatrix} \tilde{C}(t) \\ \tilde{A}(t) \end{bmatrix} + \begin{bmatrix} 0 \\ (r - n)a_\omega \end{bmatrix} \tilde{\omega}(t), \quad (\text{B.7})$$

where the time path for after-tax labor earnings, $\tilde{\omega}(t)$, is derived from the investment system [see eqs. (3.7), (3.8) and (3.9)].

The saving system (B.7) is solved by using Laplace transforms. The Laplace transform, $L_p(s)$, of a function $p(t)$ is defined by

$$L_p(s) = \int_0^{\infty} e^{-st} p(t) dt \quad (\text{B.8})$$

The appendix uses the following expression for the Laplace transform of the time derivative of a function $p(t)$:

$$L_{\dot{p}}(s) = \int_0^{\infty} e^{-st} \dot{p}(t) dt = sL_p(s) - p(0). \quad (\text{B.9})$$

Taking the Laplace transforms of (B.7) and using (B.9), one can solve for the Laplace transforms of consumption and financial wealth according to

$$D(s) \begin{bmatrix} L_{\tilde{c}}(s) \\ L_{\tilde{A}}(s) \end{bmatrix} = \begin{bmatrix} s - (r - n) & -\frac{(n + \theta)\Delta}{a_c(r - n)} \\ -(r - n)a_c & s - \left(\frac{r - \delta}{\sigma}\right) \end{bmatrix} \begin{bmatrix} \tilde{C}(0) \\ a_{\omega}(r - n)L_{\tilde{\omega}}(s) + \tilde{A}(0) \end{bmatrix}, \quad (\text{B.10})$$

where the determinant $D(s)$ of the elasticity matrix is defined by

$$D(s) = \{s - (r + \theta)\}(s + h^*). \quad (\text{B.11})$$

B.4. The solutions

The short-run change in financial wealth, $\tilde{A}(0)$, is given from the investment system by (3.5) and (3.4). To pin down the *initial change in consumption*, $\tilde{C}(0)$, one uses the condition that $L_{\tilde{c}}(r + \theta)$ is bounded.²³ This implies that the first row of the right-hand side of (B.10) should be zero which gives rise to

$$\frac{a_c}{\Delta} \tilde{C}(0) = \frac{\tilde{A}(0)}{(r - n)} + \frac{a_{\omega}}{r + \theta} \tilde{H}(0), \quad (\text{B.12})$$

where I have used [from (A.14)]

²³See, for example, Judd (1982). This latter paper explains the use of Laplace transforms to solve for linearized perfect-foresight models.

$$L_{\tilde{\omega}}(r + \theta) = \frac{\tilde{H}(0)}{(r + \theta)}. \quad (\text{B.13})$$

In fact, (B.12) is the log-linearized version of (2.6) for $t=0$. Substituting (3.5), (3.4) and (3.10) into (B.12), one derives (4.1) and (5.2).

The *time path for aggregate consumption* (5.1) is derived by substituting (B.12) and (B.13) into the first row of (B.10) to eliminate the initial change in financial wealth:

$$L_{\tilde{c}}(s) = \left[\frac{s - (r + \theta)}{D(s)} \right] \tilde{C}(0) + \left[\frac{\Delta(n + \theta)a_{\omega}}{D(s)a_c} \right] [L_{\tilde{\omega}}(r + \theta) - L_{\tilde{\omega}}(s)]. \quad (\text{B.14})$$

The Laplace transform of after-tax labor earnings is found by using (3.7), (3.8) and (3.9):

$$L_{\tilde{\omega}}(s) = \frac{[\tilde{\omega}(0) - \tilde{\omega}(\infty)]}{(h + s)} + \frac{\tilde{\omega}(\infty)}{s}. \quad (\text{B.15})$$

Hence, one can write the last term in square brackets on the right-hand side of (B.14) as

$$\frac{L_{\tilde{\omega}}(r + \theta) - L_{\tilde{\omega}}(s)}{[s - (r + \theta)]} = \frac{\tilde{\omega}(0) - \tilde{\omega}(\infty)}{(h + r + \theta)(h + s)} + \frac{\tilde{\omega}(\infty)}{(r + \theta)s}. \quad (\text{B.16})$$

Substituting (B.11), (B.16) and (B.6) into (B.14) yields

$$\begin{aligned} L_{\tilde{c}}(s) = & \left[\frac{1}{s + h^*} \right] \tilde{C}(0) + \left[\frac{h^*}{s(s + h^*)} \right] \tilde{\omega}(\infty) \\ & + \left[\frac{h^*}{(s + h)(s + h^*)} \right] \left[\frac{r + \theta}{r + \theta + h} \right] [\tilde{\omega}(0) - \tilde{\omega}(\infty)]. \end{aligned} \quad (\text{B.17})$$

Inverting the Laplace transforms, one arrives at (5.1) and (5.3).

The second row of (B.10) is used to find *the time path for financial wealth* (6.2). Eliminating the initial jump in consumption, $\tilde{C}(0)$, from (B.12), and using (B.11), one can rewrite this row as follows:

$$L_{\tilde{A}}(s) = \frac{a_{\omega}(r - n)\Delta[L_{\tilde{\omega}}(s) - L_{\tilde{\omega}}(r + \theta)]}{D(s)} + \frac{a_{\omega}(r - n)L_{\tilde{\omega}}(s) + \tilde{A}(0)}{(s + h^*)}. \quad (\text{B.18})$$

Substituting (B.15) and (B.16) into (B.18):

$$\begin{aligned}
L_{\tilde{A}}(s) = & \left[\frac{1}{s+h^*} \right] \tilde{A}(0) + a_\omega(r-n) \left[1 - \frac{\Delta}{r+\theta} \right] \frac{\tilde{\omega}(\infty)}{s(s+h^*)} \\
& + a_\omega(r-n) \left[1 - \frac{\Delta}{(h+r+\theta)} \right] \left[\frac{\tilde{\omega}(0) - \tilde{\omega}(\infty)}{(s+h)(s+h^*)} \right]. \tag{B.19}
\end{aligned}$$

Inverting the Laplace transforms and using the log-linearized version of [from (B.4) and (B.6)]:

$$\frac{A}{\omega} = \frac{(r-\delta)/\sigma}{(r+\theta)h^*}, \tag{B.20}$$

one arrives at (6.1) and (6.2).

Appendix C: Pareto-improving tax reform

Expression (9.2) is found by deriving the impact on discounted consumption $(r-n)L_{\tilde{C}}(r-n)$. This ‘efficiency’ effect is derived by taking the Laplace transform of (7.5) at frequency $s=(r-n)$ and using (B.9) to arrive at

$$L_{\tilde{T}_B}(r-n) = 0, \tag{C.1}$$

where we have used $\tilde{F}(0)=0$ [from (9.1) and (7.3)]. Using (7.7) and (7.6) to rewrite the discounted trade balance, one finds

$$a_c L_{\tilde{C}}(r-n) = (\alpha_k - a_I) L_{\tilde{k}}(r-n) - a_I L_{\tilde{x}}(r-n). \tag{C.2}$$

The last term on the right-hand side of (C.2) is rewritten using (A.5) and (B.9) to arrive at

$$a_c(r-n)L_{\tilde{C}}(r-n) = t_k \alpha_k \left(\frac{h}{h+r-n} \right) \frac{\sigma_k}{(1-\alpha_k)} (\tilde{t}_k - \tilde{t}_I), \tag{C.3}$$

where we have used (3.1) and (3.2) to eliminate discounted capital accumulation.

The constant path of labor earnings that corresponds to this efficiency effect is found by using (B.17) at frequency $(r-n)$ and setting $\tilde{\omega}(0) = \tilde{\omega}(\infty) = \tilde{\omega}^*$:

$$a_c L_{\tilde{C}}(r-n) = \frac{a_c}{\Delta} \tilde{C}(0) + \frac{a_c h^*}{\Delta} \frac{\tilde{\omega}^*}{(r-n)}, \tag{C.4}$$

where I have used $\Delta = r-n+h^*$ [from (5.4)]. The initial jump in consump-

tion, $\tilde{C}(0)$, follows from (B.12) with $\tilde{A}(0)=0$ [from (9.1) and (3.5)] and $\tilde{H}(0)=\tilde{\omega}^*$ [from (A.14)]:

$$\frac{a_c}{\Delta} \tilde{C}(0) = \frac{a_\omega}{r+\theta} \tilde{\omega}^*. \quad (\text{C.5})$$

Substituting (C.5) into (C.4) and using (B.6) to eliminate a_c yields

$$a_c(r-n)L_{\tilde{C}}(r-n) = a_\omega \tilde{\omega}^*. \quad (\text{C.6})$$

Combining (C.6) with (C.3), one arrives at (9.2).

The time path for transfers that maintains after-tax labor earnings at the level given by (9.2) meets the following relation:

$$\tilde{l}(t) + a_\omega \tilde{\omega}(t) = a_\omega \tilde{\omega}^*(t), \quad (\text{C.7})$$

where $\tilde{l}(t)$ represents the change in debt-financed lump-sum transfers relative to domestic income and $\tilde{\omega}(t)$ is defined by expressions (3.7), (3.8) and (3.9). Substituting these latter equations as well as (9.2) into (C.7) to eliminate, respectively, $\tilde{\omega}(t)$ and $\tilde{\omega}^*(t)$, one arrives at (9.4). Expression (9.6) is found by using (9.5) to eliminate \tilde{t}_l from (9.4). Expression (9.7) is derived from (C.1) by setting $\tilde{l}(t)$ equal to zero.

Finally, expression (9.8) is arrived at by using (5.1) and (5.3) with $\tilde{\omega}(0) = \tilde{\omega}(\infty) = \tilde{\omega}^*$:

$$a_\omega \tilde{C}(t) = a_\omega \tilde{\omega}^* + (a_\omega \tilde{C}(0) - a_\omega \tilde{\omega}^*) e^{-h^* t}. \quad (\text{C.8})$$

Substituting (5.4) and (B.6) into (C.5) to eliminate h^* and a_c and using the result in (C.8) to eliminate $\tilde{C}(0)$ yields (9.8).

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